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THE ANNALS OF APPLIED BIOLOGY

THE OFFICIAL ORGAN OF THE ASSOCIATION OF ECONOMIC BIOLOGISTS

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The Association of Economic Biologists

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VOLUME I MAY, 1914 No. 1

THE ANNALS
OF
APPLIED BIOLOGY

EDITORIAL.

THE Association of Economic Biologists was founded ten years ago and commences herewith the publication of a journal devoted to the special interests of its members. During this period its scope has broadened and the *Annals of Applied Biology* is intended to cover the ground in applied biology which is not now covered by special journals such as those dealing with agricultural science, parasitology, genetics and medical science.

Whilst the membership of the Association includes those who contribute to these special journals, it is now intended to deal especially with other branches of applied biology, and we are glad to be able to issue in our first number a wide range of papers, which will soon become still wider.

All papers which bear on the scientific problems of applied biology will be welcome; we have no place for purely systematic work which is amply provided for elsewhere, nor for faunistic work as such.

The Association. The Association was founded in 1904 with headquarters in Birmingham and has since held meetings at which papers on biological subjects were read and discussed. The headquarters are now in London, and it is hoped to hold meetings quarterly, usually in London, but with one meeting annually elsewhere.

There is room for a wider membership in the Association, which aims at drawing together workers in applied biology, and if that membership can include a large majority of those engaged in research and teaching, and those in official positions, the influence of the Association could be applied both to public opinion and to national affairs in a measure wholly impossible in the past.

We hope to secure the support of workers in the Dominions and Colonies. Few people realise how great is the progress made in applied biology in the Over-seas Dominions during the last twenty years and how vital to the success of all tropical industries is the work that is being done in applied biology ; it has become evident in regard to medicine, but is less realised in agriculture, horticulture, animal breeding, and other industries in which investors at home are interested ; nevertheless, such industries depend for their continued prosperity more and more on research in biology and the application of its results.

The Association will attempt to form a link between workers in Great Britain and in the Dominions, and the support of colonial members of the Association is as vital to success as that of their fellow-workers in this country.

Towards effecting this, the publication of a journal may have a great influence and we hope to attract not only the more solid scientific contributions but also notes of progress, of interesting achievements, of practical problems, as they present themselves to members in the various parts of the Empire.

We have lately made a wide appeal for membership, since we believe that only by organisation will the applied biologist be in a position to establish his subject as one of profound importance in the future welfare of the Empire. The recognition of the important part played by biology is as yet very imperfect, even in the minds of the most advanced officials of State Departments and Colonial Administrations ; large problems, in which technical knowledge is required, are settled without the technical expert being seriously consulted and this is the fault, not of the official mind or of the man-in-the-street's attitude, but of the applied biologists themselves. Medical men are organised and that so successfully that in a present problem, largely entomological, the medical interest has tended to prevent all recognition of the value and need of the entomologist's services ; we refer to the tse-tse fly problem in Africa but we could quote other similar cases ; at the recent Phytopathological Congress in Rome the technical experts were outnumbered by the diplomats and no country had been able to give its experts a deciding voice in the Congress, though the questions involved were admittedly technical and could be decided only by experts.

We see this attitude daily and every biologist in the Empire suffers from this sooner or later ; it was once a custom in India to appoint a medical officer to any scientific post, simply because science was so vague a conception to the senior official, educated in the classics, that

he could not conceive subdivisions of science requiring technical expert advice: that day is gone in India but there is still much to teach the official, as also the man in the street, in this respect.

If then the applied biologist is to make himself felt, it will be through an organisation comparable to those by which the chemists, the engineers and the doctors assert themselves; we hope to make the Association such an organised body: the publication of the *Annals* will be a means to that end and we ask all applied biologists to support it, to join the Association and to induce others to do so too.

The Library. There is at present no centre in London where the literature of applied biology can be consulted or obtained on loan. Societies such as the Zoological, Entomological, and Linnaean, maintain libraries of systematic and purely scientific literature, but scarcely any at all of the applied aspect. It is proposed to found the nucleus of a library of applied biology and in this connection an appeal is made to members to send:

(1) Separates of all papers they have published so far as these are available.

(2) Separates of those they have received which they do not specially want and duplicates.

(3) Parts or sets of any periodicals they do not need.

(4) Books they can spare.

This is an experiment in this sense, that it is not yet certain that the library can be maintained; but members are asked to send separates, etc. under these conditions:

(1) All will be acknowledged.

(2) All will be kept in a room at the Royal College of Science, open to all members.

(3) All will be card-indexed under author and subject.

(4) All will be registered with the name of the lender and under the condition that, should the library be broken up or not maintained, they will be returned to the lender.

(5) So far as possible, they will be available for loan, personally or by post, on the borrower signing a receipt, and an undertaking to return them or be liable for their return or replacement.

(6) The Association will pay postage out, the borrower postage back.

It is probable that the foundation of a library will be of the greatest value to members, and when the membership has increased the income of the Association will enable the library to be added to and made of

greater value. In the present venture, no expenditure is entailed on the Association beyond postage; the whole library will be, for the present, on loan, but when it becomes possible, the Association will establish a permanent library and ask all lenders to definitely donate or resume their contributions. A library fund has been established to which contributions of any amount are invited.

Meetings. Members resident in the United Kingdom are reminded that the meetings will now be quarterly and before this appears the first will have been held.

Members are informed that it is proposed to have the next meeting after the International Agricultural Conference in London, which ends about June 30th. We hope that all members home from the Colonies or India will attend; the library room kindly lent us by the Imperial College of Science, South Kensington, is available for members and contains the present small nucleus of our library.

H. MAXWELL-LEFROY.

IMPENDING DEVELOPMENTS IN AGRICULTURAL ZOOLOGY.

By Professor F. W. GAMBLE, F.R.S.

The endowment of research in Agricultural Zoology by the Development Commissioners is a sign of the increased interest in the possibilities of the application of this subject to actual practice. Hitherto entomology only has been considered of value in regard to agriculture and though other classes of animals have long been known to exert an important influence upon the yield of crops and stock, yet no advance has hitherto been made in their study which can compare with that accomplished in the case of insects. Now however the Board of Agriculture has asked the University of Birmingham to take up these hitherto neglected branches of zoological study with special reference to helminthology and a beginning has been made both with this subject and with the protozoology of the soils.

In the present article I propose to discuss briefly some of the problems that lie before the investigators in this latest application of zoology to agriculture. Taking first, the organisms of soils (other than insects) the primary impression is the need for an ordered body of systematic knowledge such as entomologists already possess in virtue of the longer study and larger number of devotees which this subject has attracted. There has been up to the present no concerted attempt in any country to determine the biological factors of the soil, their relations to its qualities, to seasonal changes, or to its fertility. Efforts have been made at the Rothamsted Laboratory and elsewhere to determine the effects of certain protozoa; and in Italy a movement for the study of soil organisms is in its inception. But we have at present no estimate based on any but exceedingly small samples, of the animal factors, estimated either qualitatively or quantitatively, that are present in the soil. Dr Russell and Dr Hutchinson have brought forward evidence that the factor limiting the accumulation of one or more of the essential substances for plant production is a biological and not a chemical one.

And Mr Goodey, working at first on their samples and more recently at the new Birmingham Station, has determined the protozoan fauna of certain small samples of soil, the properties of which have been tested in other ways at the Rothamsted Station. By these and other allied observations carried out by C. H. Martin and Lewin in this country and by A. Cunningham in Germany, it appears that a rich fauna of ciliate, flagellate, and amoeboid protozoa are present in certain soils; that some of them at least are capable of active life therein under ordinary conditions; and that they are to be seen, when raised in cultures, ingesting masses of bacteria. Much work however still remains to be done on these organisms both from the purely zoological aspect and from the point of view of their effect upon soil fertility, and inasmuch as sound results on the life-history of protozoa involve concentrated study continued over a long period, it would be idle to expect a rapid advance in such a difficult field of research. There can be no doubt however that the results will be of great interest both to the science and practice of husbandry.

Another branch of soil science which is being promoted at Birmingham University relates to the free-living Nematodes and to those of parasitic or saprophytic tendencies.

That these play an important part in soil metabolism and in the germination and growth of crops can hardly be doubted, but no data are as yet forthcoming except for those essential parasitic species of *Tylenchus* and *Heterodera* that occur sporadically on various cereals and vegetables.

The case of the recent serious outbreak of disease in the rice fields of Bengal shows how important the study of these eelworms may prove. The rice-plant in certain districts dies off in patches or the crop may fail altogether from the attack of Ufra disease. This term "Ufra" meaning "from above" suggests that the blight is due to atmospheric conditions, but an investigation conducted by the Agricultural Research Institute at Pusa (Bulletin No. 34, 1913, *Diseases of Rice* by E. J. Butler, M.B.) has shown that the main cause of "Ufra" is not atmospheric but is a small Nematode, *Tylenchus angustus*, which by injuring the epidermis of the unprotected parts of the rice-shoot causes weakening, discolouration and ultimately the death of the plant. Moreover as this worm multiplies rapidly and swims through the muddy fields from one plant to another, a single focus of infection may spread over a considerable area in a short time. The serious nature of the outbreak lies in the proximity of the infected district to the great rice-producing countries

in Northern India. On the west of this district at the head of the Bay of Bengal, lie the extensive paddy fields of the Province, whilst on the east is the great export rice-growing tract of the Irrawaddy Delta. The investigation has been conducted chiefly by Dr Butler the mycologist at Pusa, but it is to be hoped that the Indian Government will realise the importance of having a trained helminthologist to prevent the extension of what is perhaps the most serious blow that could befall an oriental peasantry—the loss of the paddy crop.

There is however no need to go so far afield as India to illustrate the importance of research on soil Nematodes, and Mr Gilbert E. Johnson, M.Sc. of Birmingham University, who is taking up this group, has already shown by his interesting paper on unisexual families in the Nematode parasitic in the earthworm (*Quart. Journ. Micr. Sci.* June 1913) that there are many purely scientific as well as applied questions upon which the study of Nematodes throws light.

The part played by earthworms in regard to soil problems and plant rearing has been very inadequately ascertained, and in this subject further advances may be confidently expected. Enumeration of the earthworm fauna has proceeded apace in this country of late, chiefly through the enterprise of the Rev. Hilderic Friend and collectors inspired by him. The result has been a marked increase in the known micro-forms or Enchytreids, whilst a careful descriptive account of the structure of *Enchytreus pellucidus* by Mr H. H. Stirrup, M.Sc. (*Proc. Zool. Soc.* 1913) has added much needed anatomical evidence on certain points though it leaves the important question of the eggs and their mode of deposition unsettled. What is wanted, however, more than anything else with regard to this group, is an estimate of its effect upon plants and soils.

Coming now to the parasitic helminths, there has been a great increase in recent work carried on chiefly by Dr Shipley and members of the Grouse Commission in this country, in America, Germany, Italy, and France. This has confined itself largely to systematic and anatomical features and there is a great deal still to be made out with regard to the life-histories of even the commoner Nematodes and Platyelmia, whilst curative or preventive measures are as yet in their infancy. Farm stock, poultry and game in most countries are more commonly infected with these verminous parasites than is generally supposed. The farmer may know the fact well enough and he often finds a cheap and effective method of ridding his stock of these pests by the application of a vermifuge in early autumn ; but it is not always that his stock

responds to this curative treatment, and although evidence is at present hard to obtain except by personal visits, yet it points to the serious incidence of husk and other round worm diseases in certain districts, whilst the severe stomach worm disease seems at present to be waning in extent of range and intensity. There is however a very real need of dealing more fully with these animal parasites from all points of view than has ever been undertaken before and to this end the Board of Agriculture has approved the appointment of Dr Chas. L. Boulenger as Reader in Helminthology at Birmingham University. It is to be hoped that the other centres, such as Liverpool and London Universities where similar work is organised and other Research Institutions where animal nutrition and animal pathology are dealt with, will co-operate with Birmingham in regard to the difficult common problems that arise in connection with prevention of stock from these verminous diseases.

One general conclusion is reached on considering the future that lies before zoological research as applied to agriculture. It is that mutual assistance between the man on the land and the worker in the laboratory or in the field is essential to progress. We need a careful census of the country, a census that is of the animals and the animal-borne diseases affecting agriculture. We need more work, far more work, on the life-histories of the groups in question, whether indifferent, noxious or beneficial. But more than these, there is required a real and mutual understanding between the stock owner and the investigators and between the investigators of different countries working at similar problems. An organised study of animal parasites is now in progress in most civilised countries, and renewed interest in the subject has spread like a wave in the last few years. Schools of research are growing up in Egypt, in Australia, Japan and China, so that a means of coordinating the activities of such scattered workers is highly necessary. May this new journal be effective in promoting the progress of research by encouraging such mutual understanding!

THE ACTION OF BORDEAUX MIXTURE ON PLANTS.

By B. T. P. BARKER, M.A., AND C. T. GIMINGHAM, F.I.C.

(*University of Bristol; Agricultural and Horticultural Research Station.*)

In the course of experimental work involved in the investigation of the fungicidal action of Bordeaux mixture[1], a number of observations have been made on the inter-action between the spray fluid and the plants with which it comes into contact in the process of spraying. Further attention has now been given to this part of the subject and as the results help to explain various points arising in practical spraying, it is proposed to give an account of the experiments here.

It will be most convenient to consider the work in two sections, dealing with (*a*) spray injury or "scorching" by Bordeaux mixtures, and (*b*) the penetration of copper from Bordeaux mixtures into the plant.

Foliage Injury or Scorching by Bordeaux mixture.

The injury to foliage, more or less pronounced, which is frequently found to follow the application of Bordeaux mixture, has been the subject of a good deal of work, especially in America. As regards its possible bearing on the question of the *fungicidal action* of Bordeaux mixtures, the matter is discussed shortly in Section II of the second paper referred to. In considering the various means by which copper might be brought into solution on the surface of sprayed leaves, the suggestion was then made that some importance should be attributed to the influence of exudations from injuries to the leaves; and it was further suggested that if soluble copper is produced in this way, it would probably show its presence by causing or intensifying scorching. This point has been followed up in some detail.

In order to have reliable material for experimental work in this

[1] See *Journn. Agric. Sci.* IV, p. 69; *ibid.* IV, p. 76.

connection, it was essential to obtain apple foliage known to be entirely undamaged. As is generally recognised, it is almost impossible to find any number of apple leaves, when grown under ordinary conditions, which are really free from minute injuries of some sort or another. It was therefore found necessary to grow foliage specially protected from liability to injury. With this object, a number of one year old apple seedlings in small pots were carefully cleaned before the leaf buds

1 2

Fig. 1. Foliage undamaged and treated with "no-excess-lime" Bordeaux mixture.
Fig. 2. Foliage damaged with scratches and cuts and sprayed with water.

opened and each one enclosed in a muslin cage supported on a light frame. The plants were kept in a cool greenhouse and the new foliage put out was thus almost completely protected from the chance of damage by bruising or by insect attacks. A few leaves on some of the plants were slightly attacked by apple mildew, but these were always removed before starting an experiment.

When the leaves were fairly well developed, the plants were uncovered and the following series of experiments was carried out:

Plant No. 1. Leaves covered with ordinary Bordeaux mixture (*i.e.* containing large excess of lime).

Plant No. 2. Leaves first artificially damaged with scratches and pin-pricks and then treated as No. 1.

3

4

Fig. 3. Foliage damaged with scratches and cuts and treated with "no-excess-lime" Bordeaux mixture.

Fig. 4. Foliage damaged with pin-pricks and treated with ordinary Bordeaux mixture.

Plant No. 3. Leaves covered with "no-excess-lime" Bordeaux mixture[1].

Plant No. 4. Damaged exactly as No. 2, and the leaves then covered with the "no-excess-lime" mixture.

[1] This expression is used to indicate a mixture of copper sulphate and lime water in such proportions that the whole of the copper is precipitated in the form of the basic sulphate 10 CuO, SO_3 (Pickering).

Plant No. 5. Damaged exactly as No. 2, and then sprayed with water.

On the day following the treatment, there was not the least trace of injury or scorching noticeable on plants Nos. 1 and 3; whereas Nos. 2 and 4 showed very serious injury typical of Bordeaux scorch, and moreover the injuries in every case had quite obviously begun at the artificially damaged spots, and afterwards spread. The scorching was

5

6

Fig. 5. Foliage damaged by aphis and treated with "no-excess-lime" Bordeaux mixture.
Fig. 6. Foliage damaged by bruising and treated with "no-excess-lime" Bordeaux mixture.

very much worse in character and more widespread in No. 4 than in No. 2; No. 5, the plant sprayed with water, showed a browning along the extreme edges of the scratches and spots, but no spreading of injury. Other plants belonging to the same batch as those used in the above trials but which had been allowed to develop their foliage without special protection in the greenhouse were covered with the "no-excess-lime" mixture and included in the series; these showed slight scorching

especially round the edges of the leaves. These results have been confirmed several times.

In another series, aphides were introduced into the muslin cage surrounding the foliage and allowed to increase until many of the leaves were badly infested; the plants thus damaged were then covered with the "no-excess-lime" mixture. The result was very bad scorching, largely confined to the underside of the leaves where they were most damaged by aphis.

The relative degrees of injury under various conditions are shown in the accompanying drawings, the shaded portions representing browning of the leaf.

Similar experiments with the protected foliage of apple shoots standing in water gave confirmatory results. The leaves in this case being much less well developed were mostly entirely killed by the Bordeaux where the artificial damage had been at all severe, but undamaged leaves remained healthy. It was found, further, as was to be expected, that these effects were very much more marked when the Bordeaux was put on soon after the damaging of the leaves. In a moist atmosphere, bad "scorching" followed treatment with the spray fluid up to 24 hours after the damage had been done; if a 48 hour interval was allowed, the effect was markedly less severe and after 72 hours it was very slight. In a fairly dry atmosphere both out of doors and in the greenhouse, the "scorching" following treatment 18–24 hours after the leaves were damaged, was not very serious; although in some cases it got noticeably worse after several days. In these experiments the damage to the leaves was made as far as possible equally by means of pins fixed in a cork, and the spray fluid was usually put on the leaves with a brush so as to ensure a uniform coating.

We have then definite evidence of the importance of the presence of artificially or naturally damaged foliage in considering the scorching by Bordeaux mixture. The extreme difficulty of finding leaves which have altogether escaped damage has already been mentioned; and has been experienced by many other workers. Crandall[1] in America, for example, made a careful examination of 6000 leaves taken at random from 60 different trees and found only 27 (less than 0·5 %) which he could call perfect leaves; although the appearance of the foliage on these trees, on the whole, was good. Wallace[2] in his work on spray injury by lime-sulphur preparations also emphasises the rarity of

[1] *Univ. Illinois Agric. Expt. Sta. Bull.* 135.

[2] *Cornell Univ. Coll. Agric. Bull.* 288.

uninjured leaves, and both he and Crandall and other workers have drawn attention to the fact that, in practice, foliage which is badly attacked by insect or fungus pests or otherwise badly injured is specially liable to serious damage by scorching. Pickering also refers to the effect of injuries in intensifying scorching[1].

There is then no doubt whatever that even slight injuries to the leaf cuticle, if they have not had time to dry up, play an important part in determining the extent of scorching, following spraying with Bordeaux mixtures. Summer foliage, known certainly to be undamaged, as far as our experiments go, shows no scorching.

In order to explain the increased scorching due to leaf injuries, it is necessary to account for the production of copper in a soluble form. Until lately the view has been generally accepted that atmospheric agencies, and in particular carbon dioxide, are responsible for the production of soluble copper sulphate from the insoluble basic copper sulphate which is deposited on the leaf. Both the fungicidal action and the scorching are attributed to the copper sulphate thus formed. It has, however, been shown by one of us[2] that from the chemical standpoint this view is not tenable; the fungicidal action of Bordeaux mixture cannot be put down to copper sulphate liberated by the action of atmospheric carbon dioxide; and the experimental evidence for this statement is equally applicable with reference to the scorching action. The authors have further shown[3] that the fungicidal action of Bordeaux mixture is very largely, if not entirely, due to an inter-action between the fungus and the particles of the insoluble basic sulphate with which it comes in contact; the fungus dissolving and absorbing enough copper to kill itself. In the same way the simplest explanation of the enhanced scorching of damaged, as compared with undamaged, foliage is, that soluble copper compounds[4] are produced by the solvent action of exudations from the injured cells and from those underlying, which are exposed by the injury, and that these substances are then absorbed through the thin-walled cells of the internal tissues of the leaf. It is then easy to understand the gradual spreading of the spots from a centre which is observed in most cases of Bordeaux scorch. Serious scorching occurring several days or even weeks after the actual spraying is probably to be

[1] 11*th Rep. Woburn Exptl. Farm*, p. 123.

[2] *Journ. Agric Sci.* IV, p. 69.

[3] *Ibid.* IV, p. 76.

[4] Soluble copper produced in such manner may, as previously suggested, also act fungicidally.

accounted for by rough weather causing damage to the foliage, or by a serious insect attack. Again the general opinion of practical men[1] that the severity of Bordeaux injury is determined by the weather conditions at the time of spraying and that the injury is most serious when rain immediately follows the spraying fits in well with the view here suggested, since in wet weather any injuries present will heal over much less quickly and will therefore be capable of dissolving copper during a longer period.

In view of these considerations as to the important part played by imjuries to the leaf surface in determining the extent of Bordeaux scorching, it becomes interesting to enquire whether the presence of such injuries is the sole cause or whether Bordeaux mixture does ever cause scorching on *undamaged* leaves. This is not an easy point to settle satisfactorily. It appears that, as recorded above, there is no noticeable scorching of foliage which has been carefully protected ; and indeed we have a good deal of evidence emphasising the impenetrability of the undamaged leaf cuticle of ordinary healthy summer foliage. For example, the general surface of healthy leaves stands immersion in 5 % or even 10 % copper sulphate solution remarkably well ; and on repeating many of the experiments with damaged and undamaged foliage described above, but using 5 % copper sulphate solution in place of the Bordeaux mixture, almost identical results were obtained. The damaged leaves indeed "scorched" worse with copper sulphate than with the Bordeaux mixture, but the undamaged leaves remained almost entirely unaffected, unless the time of contact was very prolonged.

The general conclusion which may be drawn from a large number of experiments on the effects of solution of copper sulphate upon the foliage of different varieties of apple is that, except where the leaves are originally damaged in some way, a short time of contact with a weak solution causes little or no immediate injury, though a longer time of contact may initiate injury to the under surface[2]. Even, however,

[1] Confirmed experimentally by Crandall (*loc. cit.*) and by Hedrick (*New York Agric. Expt. Sta. Bull.* 287).

[2] It is somewhat difficult to understand exactly what is the position taken by Crandall with regard to this point. On p. 232 of his Bulletin, after describing some experiments, he concludes that "the uninjured epidermis of apple leaves was not permeable by copper sulphate solutions": whilst his conclusion No. 16 runs ". . . . burning quickly follows applications of copper sulphate even when the solutions are very dilute." Possibly the latter statement refers only to damaged foliage, in which case his observations are in full agreement with those here recorded.

after immersion for one hour in a 5 % solution or for half an hour in a 10 % solution the general surface of healthy leaves is not seriously injured. It must be mentioned, however, that with all leaves, damaged or undamaged, treatment with copper sulphate affected the hairs on the under surface, resulting in slight yellowish discolouration, which on close examination were found to be due to the staining of the cell walls. It also hastened the death of late autumn foliage.

By coating one or other of the surfaces of the leaf with vaseline, it was possible to compare their behaviour towards copper sulphate solution, and it was thus found that the upper surface, where quite free from damage, possesses a remarkable power of resistance to the penetration of the solution. Even when the liquid was allowed to dry on the leaves, injury to the upper surface was confined to certain areas, usually evidently arising from some original damage. The under surface is more easily affected: possibly the presence of stomata (in the apple) on the under surface of the leaf only may have some bearing on this point.

These observations apply, however, only to summer foliage. When similar experiments are tried in the late autumn the results are different. The effect of covering autumn leaves, whilst still on the trees, with "no-excess lime" Bordeaux mixture is to cause considerable and apparently general scorching over most of the leaf surface, accompanied by premature defoliation. When ordinary Bordeaux mixture (containing excess lime) is used, there is more scorching than is noticed in the summer, but the action is not severe. With 5 % copper sulphate solution the leaves very soon shrivel up and drop, and the presence of copper can be traced inside the stem lower down than the parts actually immersed[1]. There is in these cases apparently a general scorching independent of the presence of visible injuries, and of a somewhat different character to that which occurs in the summer. The cuticularised walls of the cells are found to be stained a pale greenish colour, in a manner similar to the leaf-hairs already mentioned.

Possibly under autumnal conditions changes take place in the nature of the cuticle, which lead to the production and absorption of soluble copper over the general surface of the leaf, the Bordeaux mixture thus damaging underlying cells in spite of the really uninjured leaf surface. On the other hand, the possibility of the presence of small injuries was not entirely excluded in these experiments, though the foliage was chosen for its generally sound appearance.

[1] See also p. 18.

The behaviour of apple foliage in the summer condition towards Bordeaux mixture appears to be typical of that of a variety of other hardy plants. The leaves of wallflowers, privet, and violet have been similarly tested and in each case there has been no scorching of uninjured foliage. It is well known, however, that very great variations in susceptibility to scorching are shown by different plants. Some are peculiarly susceptible, and in such cases the general character of the scorching strongly suggests that a change in the nature of the cuticle or, perhaps, the presence of groups of uncuticularised cells rather than local injury is responsible. It is possible that the cuticle in these instances is normally more or less permeable, just as the cuticle of apple leaves appears to become in autumn. Salmon's work[1] on the susceptibility of certain varieties of gooseberries to scorching injury after spraying with lime sulphur washes of various strengths appears to bear out this point; varieties such as Lancashire Lad, Crown Bob, and Berry's Early remaining unaffected by the spray when treated in early summer, while later a wash of the same strength causes scorching. It was also shown that certain kinds such as Valentine's Seedling and Yellow Rough were regularly injured, whilst others such as Whinham's Industry, Rifleman and May Duke escaped damage even when a wash of more concentrated strength was used.

It may be said in conclusion that the evidence seems complete as regards the part played by injuries to the leaves in causing scorching of apple foliage following spraying with Bordeaux mixture; whilst under some conditions it would seem that scorching might also occur over the general surface of the leaf and unconnected with the occurrence of injuries, though this is less certain. No doubt such action if it takes place is more important in foliage such as peach and apricot where either the cuticle as a whole or certain parts of the leaf surface appears to be less resistant than is the case with the apple.

The Penetration of Copper from Bordeaux mixture into the Plant.

The action of the copper of Bordeaux mixture upon plants is not confined to the surface. It is found that under certain conditions plants which have been sprayed absorb some copper either through their foliage or their roots.

Millardet and Gayon (*Journ. d'Agric. Prat.* 1887, p. 125) were the first to refer to the absorption of copper by leaves. They proved the

[1] *Journ. Bd. Agric.* XVII, p. 881; XX, p. 1057.

presence of copper in the cuticle of grape leaves which had been treated with various strengths of copper sulphate solution: no information is however given as to the condition of the leaves as regards injury. Rumm (*Ber. Deut. Bot. Ges.* XI, p. 79) and later Crandall (*loc. cit.*) found no penetration of copper from copper sulphate solutions through the cuticle of uninjured apple leaves. Pickering on the other hand (*loc. cit.* p. 113) showed the presence of copper in the ash of "perfectly sound" apple leaves treated with various copper solutions.

During the present investigation *damaged* apple foliage which has been sprayed and which shows any signs of scorching has always been found to contain some copper. Repeatedly, such leaves have been examined. The procedure adopted has been first to wash the sprayed surface in dilute acid, great care being taken to wet every portion with a brush, then to transfer the leaves to running water for half an hour or longer, after which they are dried and ignited and the ash tested for copper. In the case of scorched leaves, copper is invariably found to be present in the ash. On the other hand, with really uninjured summer apple foliage, copper has not been detected in the ash[1]. Probably the presence or absence of slight injuries is sufficient to account for the conflicting results of other workers.

A comparison of the results of dipping healthy summer and autumn apple foliage into 5 per cent. $CuSO_4$ is very striking. As has been mentioned, the summer leaves are little affected by this treatment; the autumn leaves, however, besides being severely scorched, absorb a good deal of copper which is passed down into the stem, killing all the interior cells for some distance below the portion actually immersed. Crandall has recorded a similar translocation of copper through the stem of apple trees into which solutions of copper sulphate had been injected through wounds. Browning of the leaves was also observed.

It would appear that there is no absorption of copper through the normal cuticle of a healthy apple leaf. Autumnal changes, however, as already shown, lead to a partial change in the nature of the leaf surface, and there is a varying amount of action of Bordeaux mixture resulting in injury and absorption of copper.

Turning now to the behaviour of *potato* foliage towards Bordeaux mixtures, we find rather a different state of affairs. The cuticle appears to be distinctly more permeable than that of normal apple leaves. On covering potato leaves either with the ordinary or the "no-excess-lime" mixture there is certainly some absorption of copper, for it can readily

[1] By the ferrocyanide test.

be detected in the ash of treated leaves, but on the other hand there is seldom any noticeable injury to the cuticle.

The cuticle of potato leaves is of quite a different type to that of apple leaves and either all the cells or some only (possibly the hairs) are evidently capable of exerting a slight solvent action upon the copper compounds, which gives rise to a limited absorption insufficient to cause injury to the cells. Copper absorbed in such a manner as this appears to be rapidly translocated and dispersed without harm to the living cells through which it passes. Possibly the removal is sufficiently rapid to prevent the toxic dose being reached at any one point.

Another series of experiments showed that copper can be absorbed by potatoes through their *roots*. A number of potato plants were grown in pots in soil mixed with considerable quantities of various Bordeaux mixtures, so that the tubers were actually in contact with the copper containing compounds. Samples of foliage were taken from each plant, dried, ashed, and the ash tested for the presence of copper.

The following are the notes obtained from this series on testing the foliage on two occasions separated by about a month :

Soil treated with	Copper reaction I	Copper reaction II
"No-excess-lime" mixture	Faint, but distinct	Strong
Cooper's Bordeaux powder	Very faint	Very faint
Ordinary Bordeaux mixture	Very faint—uncertain	Faint, but distinct
Control	Nil	Nil

Here again we have apparently an absorption and translocation of copper through the plant from the roots to the aerial parts without injury to cells during transmission. There is in this case some local injury to the surface of the root.

Precisely the same thing was found to occur with broad beans when these were grown with their roots in contact with the basic copper sulphate ; an appreciable amount of copper was found to be present in the leaves. Analysis of the foliage of control plants showed absence of copper. The influence of the absorbed copper was not, so far as could be observed, injurious, the amount of growth often being equal to that of the control plants, and where appreciably less, probably this was attributable to the disorganisation of the root system.

What the physiological effect of the absorbed copper may be is at present uncertain. In a set of practical spraying experiments it was noticed that in all cases (as has often been recorded) the colour of the sprayed plants differed from that of the unsprayed, being of a darker and rather bluish-green shade. This was especially noticeable in plants treated with Burgundy (Soda-Bordeaux) mixture. A further point was that the darker green colour was not confined to leaves coated with the spray. New foliage which developed after the spraying, showed the colour effect almost equally well. A comparison of sections of leaves of treated and untreated plants showed that the colour change was due mainly, if not entirely, to the difference in the nature or amount of the chlorophyll in the mesophyll tissues. It was not possible to decide positively, whether there was also a difference in the colour of the cuticular epidermal walls and of the hairs.

A colour effect was also noticed in the case of the broad beans. The foliage of the copper-containing plants was on the whole noticeably darker in colour, although considerable variation in this respect, due partly at any rate to the conditions of the experiment, was met with. In marked cases the tint of the green colour differed considerably from that of the normal leaf green of a healthy bean plant, being of a distinctly bluer or greyer character. Comparison of alcoholic extracts of chlorophyll from copper-containing and copper-free foliage by spectroscopic examination and other methods failed to reveal any difference between the two; and the colour of the extracts, unlike that of the leaves themselves, was practically identical. In making the chlorophyll extract, however, it was noticed that in the case of the copper-containing foliage there was considerable difficulty in obtaining complete extraction of the colouring matter; and generally after extraction the tissues instead of being quite colourless, contained areas of a pale purplish-black tint. Sections of the tissues showed that this colour was due not so much to colouring matter within the cells as to cell walls stained with this tint.

The question of the influence of the copper in potato and other foliage on the power of resistance of the plant to fungoid attack is still under investigation.

The results of these observations on foliage injury and the absorption of copper by the plant from Bordeaux mixtures may be summarised as follows:

(1) Cells with readily permeable walls (such as germ tubes of fungus spores, root hairs, the interior tissues of leaves, etc.) exert a considerable

solvent action on the particles of the copper compounds with which they may come into contact. There is rapid absorption of the dissolved copper followed by death of the cells. In the case of injured foliage such action results in scorching.

(2) The amount of inter-action, if any, between other types of cells and the copper compounds is determined by the nature of the cell wall. Direct absorption of copper by leaves of certain types takes place with or without local injury, depending on the nature of the leaf surface. Translocation of the absorbed copper to other parts of the plant may follow.

(3) Copper may be absorbed through the roots of certain plants (potatoes, beans), with local injury to the root. This absorbed copper can be translocated to the aerial parts of the plants without injury to the cells through which it passes.

NOTES ON THE GREEN SPRUCE APHIS (*APHIS ABIETINA* WALKER).

By FRED. V. THEOBALD, M.A., etc.

During 1913 a very severe attack of the aphis described by Walker in 1849 as *Aphis abietina* took place on spruce trees of various kinds. This aphis I have found in considerable numbers in the south of England for many years, but I have never known it until the summer of 1913 to do any serious harm.

Since Walker's original account given in the *Annals and Magazine of Natural History*[1], the only references I know of it are those given by Buckton in his *Monograph of British Aphides*[2] in 1877 and in Gillander's *Forest Entomology* in 1908[3]. I have also recorded it from Worksop[4] in 1910 and from Kent in 1911[5]. P. Van der Goot[6] places this in his new genus *Myzaphis*. I have known however of this insect since 1889 when it was abundant on the Norway spruce at Kingston-on-Thames, and on some of the spruce trees in Richmond Park.

I can find no reference to this spruce aphis on the Continent, but I remember finding it near Odde in Norway in 1891.

Like most aphides it is of erratic appearance. Districts in which it is quite common one year, may suddenly become comparatively free from it. Then after a lapse of time it may occur again in quantity. The only years in which actual damage has been noticed however are 1846 and 1913.

It is quite possible that the damage caused by it on other occasions may have been put down to other causes, such as unsuitable soil, drought, etc.

[1] *Ann. Mag. Nat. Hist.* III, Ser. 2, pp. 301–302.
[2] *Mono. Brit. Aph.* II, p. 43, pl. xlix, figs. 3 and 4.
[3] *Forest Entomology*, p. 304.
[4] *Rept. Eco. Zool.* for year ending Sep. 1911, p. 132.
[5] *The Entomologist*, XLIV, p. 398 (1911).
[6] *Tijdschrift v. Ent.* LVI, p. 96 (1913).

There is no doubt it is influenced very largely by the weather. Its destructive nature under certain weather conditions can be understood by the notes given here and the photos showing the damage, and it may here be pointed out that both in the 1846 and 1913 attacks, that the previous winters were noted for their mildness and dampness. No doubt these conditions place the Piceas in an unhealthy condition, and that in consequence the effect of these sucking insects becomes much more marked and at the same time the mild weather enables the aphis to flourish right through the cold months.

Description of the Insect.

Apterous viviparous female.

Green, oval, convex, with a darker line on each side of the body.

A

B C

Fig. 1.

Aphis abietina Walker. A Alate female B and C Apterous viviparous females.

Head yellowish-green to fawn colour, with two foveae; a small prominence on each side of the head at the base of the antennae.

Antennae about half the length of the body, pale yellowish-green, darker at the tips, the first segment very wide, second small and narrow, third longer than the fourth, the fourth a little longer than the fifth, the sixth about as long as four and five, the basal area as long as the flagellum, which is blunt; all the segments markedly imbricated.

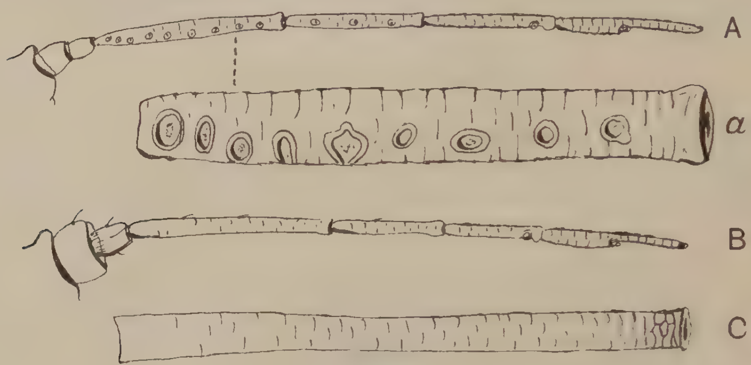

Fig. 2.

Aphis abietina Walker. *A.* Antenna of alate female *a.* further enlarged third segment. *B.* Antenna of apterous female. *C.* Cornicle of alate female.

Eyes dull red. Proboscis green, dusky at the apex, reaching to the third coxae.

Cornicles pale yellowish-green, some with a brownish tinge, apex in some dusky, about one-fourth the length of the body, a few lines and large reticulations at the apex, remainder strongly imbricated. Legs green, tarsi, tips of femora and the tibiae dusky. Cauda green, rather long.

Length, 1 to 1·5 mm.

Winged viviparous female.

Green. Head large, a pale olive green to pale fawn colour; antennae nearly as long as the body, pale brown, the third segment with 9–12 large sensoria along its whole length, the fourth shorter than the third, with 2-4 sensoria; the fifth slightly shorter than the fourth, with a sub-apical sensorium, the sixth not as long as four and five together, the basal area only a little shorter than the flagellum; all the segments markedly imbricated. Head with two prominent but small

frontal processes at the base of the antennae. Eyes deep red; stemmata prominent.

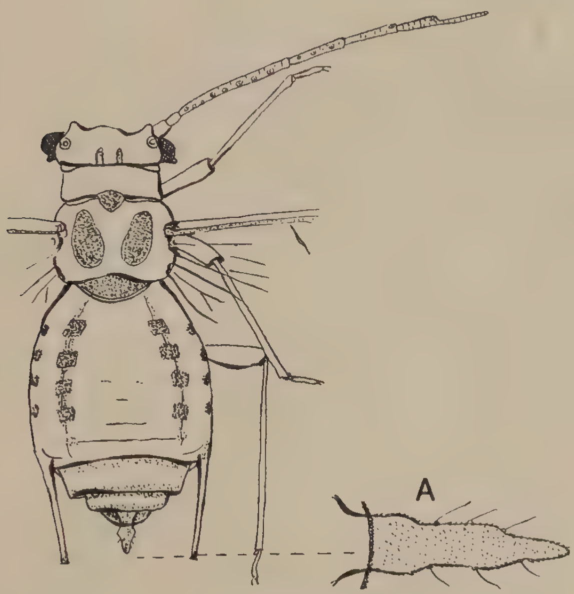

Fig. 3.
Aphis abietina Walker. Alate viviparous female and further enlarged cauda A.

Pronotum fawn coloured to green; mesonotum greenish with darker lobes, scutum and scutellum in some brown; venter of thorax dark.

Abdomen bright green with dark sub-median lines, really made up of four darker spots, also traces of four pairs of darker lateral spots; segments caudad to the cornicles marked and somewhat darker than the rest. Cauda pale green, pointed, moderately long.

Cornicles long, thin, straight, cylindrical, reaching beyond the cauda, pale greenish to greenish-brown; in some slightly darkened at the tips; apex with a few transverse lines and large hexagonal areas, not strongly imbricated.

Legs pale green in some, pale brown in others, rather short; femora thick; tarsi and apices of the tibiae slightly darkened. The wings are large, much longer than the body with rounded apices; the stigma and veins pale brownish-green to grey, subject to considerable variation in veination; the veination in the two wings often being totally unlike one another (*vide* Figs. 1 A and 4).

Proboscis green, dusky at the apex, reaching to the third pair of legs. Cauda with three long chaetae on each side.

Length, 1 to 1·8 mm. *Wing expanse,* 5 to 5·2 mm.

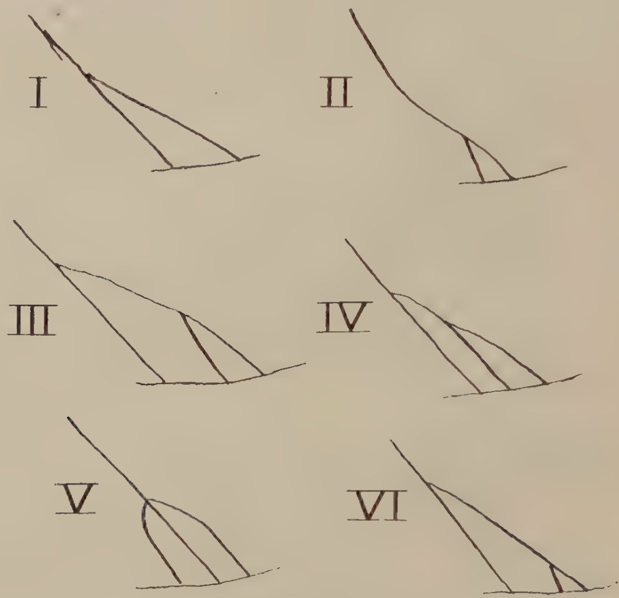

Fig. 4.

Variations in veination in *Aphis abietina* Walker.

Localities where found.

England. Alnwick, Northumberland (Gillanders); Great Lalkeld, Penrith, Cumberland (Britten); Thirlmere, Grasmere, Manchester Corporation Water Works, Westmoreland (Edwards), Windermere (Aymer Roberts); near Flamborough Head, Yorks. (Theobald); Holmes Chapel, Cheshire (Young); Great Staughton, near St Neots, Huntingdonshire; Little Hadham, Herts; Widdington, Essex; Kew Gardens, Surrey; Rudgwick, Sussex; Woking, Guildford, Worplesdon, Esher, Kingston in Surrey; Panton, near Wragby, Lincs.; Wye and Goudhurst, Kent; Tiverton, Devon; Fowey, Cornwall; Worksop (Theobald); Culford, Bury St Edmunds, Suffolk (Henry).

Wales. Aberglaslyn and Criccieth, Merionethshire[1] (Theobald).

[1] This aphis swarmed in Aberglaslyn in 1906. The attacked trees have since been cut down.

Ireland. Rathdrum, Co. Wicklow; Dundrum, Co. Tipperary; Kilrush, Co. Clare; Camolin, Co. Wexford.

I have been unable to obtain any records from Scotland.

Food plants.

There is no doubt that the genus *Picea* is the normal food plant of this aphis, but I have taken it in numbers on Scots firs on six occasions and once on a Weymouth pine at Wye.

Its normal food plant is probably *Picea excelsa*, and until recently I have not seen it on any other species of conifer except the Scots and Weymouth pine[1].

The species of *Picea* on which it has been recently found are the following:

Picea excelsa, *P. sitchensis*, *P. pungens*, *P. engelmannii*, *P. nigra*, *P. alba*, *P. gigantea*, *P. rubra*, *P. morinda*, *P. orientalis*, *P. monstrosa*, *P. omorica*, *P. kosteriana*, *P. glehire*.

Apparently immune varieties.

Certain varieties are apparently immune, such as *P. polita*, *P. hondoensis*, *P. alcoguiana* and *P. alaskiana* and in some places *P. omorica* has not been attacked.

Varied degrees of attack on different species.

Speaking generally, the Sitka spruce is by far the most damaged, but this does not apply everywhere. For instance in the small nursery belonging to Wye College I was unable in 1913 to find a single specimen of this insect on the Sitkas, but *Picea excelsa* close to them were found to have any number on them and a few were badly damaged.

At Kew *P. sitchensis*, *P. pungens* and *P. engelmannii* were badly damaged, even trees 20 to 30 feet high, *P. nigra* and *P. alba* were in some cases damaged, others escaped. It was noticed here that the European and Asiatic species were damaged much less, the only seriously injured one being *P. excelsa*.

In a large nursery I visited at Woking I found it doing great damage to *P. pungens*, *P. alba* and *P. sitchensis* and a great deal on *P. excelsa*.

In my garden one large *P. excelsa* was entirely browned by it and I think is dead, another was partly ruined, whilst *P. pungens* var. *kosteri*,

[1] I may point out here that Dr Henry in the *Gardeners' Chronicle* says the aphis has not been noticed on any genus except *Picea*.

a large needled, very glaucous form (Fig. 7) had some amount of aphis on three specimens, but two were affected scarcely at all and the aphis increased very slowly, the third however, which had been previously damaged by accident, was badly infested with this insect. All the other

Fig. 5.
Sitka Spruce attacked by *Aphis abietina* Walker. Early stage showing needles turning brown and falling.

English records I have are on *P. excelsa*. Writing from Dundrum, Co. Tipperary, Mr A. McRae says, "I find the common spruce of all ages, from nursery stock to matured trees of 80 years or over, are badly infested. On matured spruce the effects are most marked on partially

isolated trees, growing on road sides or along the margins of belts and woods, on comparatively low ground, say 300 to 400 feet altitude. I also find the aphis in comparatively large numbers on old trees of white American spruce, but up to the present they do not show any very serious results. At Dundrum the Sitka would appear to succumb most

Fig. 6.
Picea excelsa showing denudation on upper portion of shoot after a year's attack.

readily to the attack ; in the nursery, however, the Sitka are not affected to the same extent as the spruce, but the latter are larger trees and have been longer in stock than the Sitka."

Writing from Avondale, Rathdrum, Co. Wicklow, Mr J. Black sent the following list of species attacked :

P. sitchensis, badly attacked, six years planted, 8—10 feet high.

P. excelsa, attacked to some extent.

P. morinda, two years planted, partially defoliated.

P. rubra, *P. alba*, six years planted, attacked similar to *excelsa*.

P. pungens, four years planted, attacked quite as badly as *sitchensis*.

Fig. 7.

Picea pungens v. *kosteri* showing aphides but little damaged.

Single specimens attacked are as follows :

P. orientalis, slightly affected.

P. engelmannii, badly attacked.

P. kosteriana, badly attacked.

P. glehire, badly affected.

P. monstrosa, badly affected.
The only species not affected here are:
P. polita, *P. omorica*, *P. alcoguiana* and *P. alaskiana*.

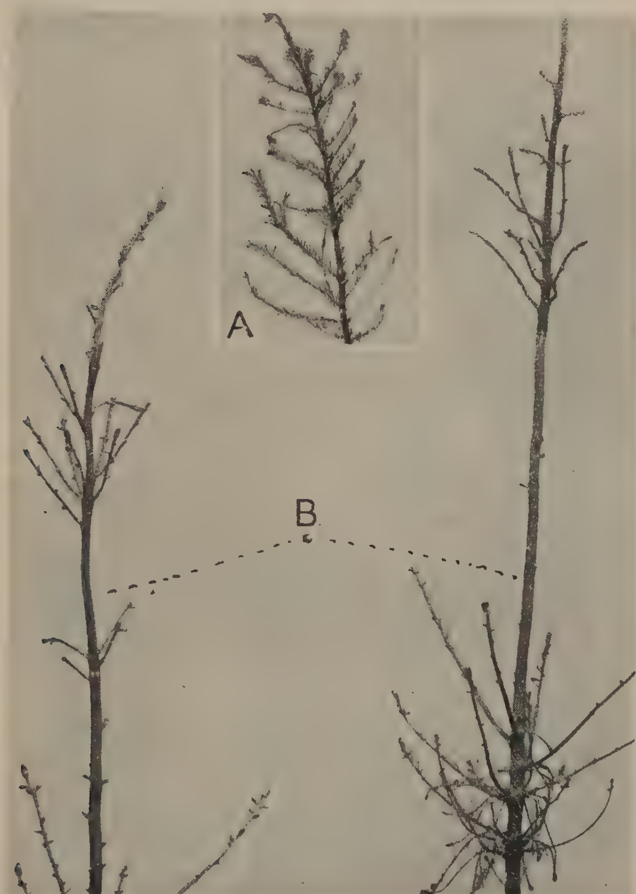

Fig. 8.
B. Sitka Spruce completely defoliated by *Aphis abietina* Walker. A. First stage of attack.

Different effects produced on different varieties.

Two very marked different effects are produced by this aphis. In *P. sitchensis* the damaged needles soon fall and complete defoliation results, as shown in the photos reproduced here. In *P. excelsa* the

needles turn brown, but the majority hang on and the tree looks as if it had been scorched by fire. In one tree in my garden the leaves have partially kept on into the spring of 1914. The damaged needles certainly fall, but nothing like to the same extent as in the Sitka spruce.

In *P. morinda* they become partly defoliated; in *P. engelmannii*

Fig. 9.

Picea excelsa showing a few fallen needles and young growth unattacked. *a.* young growth. *b.* some nodes where needles have fallen. *c.* discolouring of needle.

the trees do not become defoliated, nor in *kosteriana*; one of the latter attacked in my garden has every browned needle still holding on, much more so than in *excelsa*. Partial defoliation takes place according to Mr Black in *glehire* and *monstrosa*.

Young *excelsa* do not present the same appearance as old ones when attacked, the needles instead of turning brown are mottled, where the aphis sucks yellow spots appear and this lasts through the winter. Writing from the Camolin Forestry Centre, Co. Wexford, Mr A. Stewart says "the aphis is extremely plentiful on young Sitka and Norway spruce, but that in May not much damage had been done to the latter, but the Sitkas are in many cases practically defoliated."

Fig. 10

Sitka Spruce defoliated by *Aphis abietina* at Arndale (Dr Henry).

Mr Murphy of the Kilrush Forestry Centre, Co. Clare, found the few thousand Sitka spruce attacked, but not badly, but that both Sitkas and Norway spruce in the plantations were practically immune.

It thus seems that both the Norway and Sitka spruce are badly attacked and then next comes *pungens*, but that there is a marked

difference in the appearances produced, *i.e.* complete and rapid defoliation in the Sitka, browning and slow defoliation in *excelsa* and still less defoliation in *pungens* and scarcely any in the glaucous variety *kosteriana.*

Life-history.

So far I have been unable to find any sexuparae and I have searched carefully for four years.

I have found apterae from early January on to December. The first alatae occurred on the 20th of March at Woking, but in small numbers. At Wye I have never noticed any until June and in July many occurred and went on appearing in numbers into August. After August the trees kept under observation showed comparatively few aphis until the end of September, when they again became fairly common and some could always be found right into December. These winter apterae seldom producing any living young. At this time both mature and immature apterous viviparous females occur.

Gillanders says that it may be found in winter. Mr McRae writes me that where infestation is serious the aphis appears to live on the trees throughout the winter, and Mr Black also noticed that this aphis persists throughout the year. I have vainly searched for sexuparae this year, a year when the sexual brood of aphides has been particularly noticeable.

The apterous aphides usually occur along the needles, a single one settling on each needle and giving rise to a colony of young, which later spread out and do the same; where the apterous mother feeds a yellow spot occurs, sometimes with a reddish tinge and which later darkens; two or three of these spots on old trees seem sufficient to kill the needle, whilst in young ones they remain, the needles but seldom completely dying. The aphides also wander about on the shoots and remain and feed there.

They do not seem to attack the new growth to any extent in summer, but in autumn and winter a few may be found on the young growths.

In October and November I counted about six apterae to every foot of branch examined and a few small young with them. The insect is very sluggish both when in the apterous and alate stages, but if a branch is cut off they become active in a few hours and wander away from the needles.

It thus appears that this insect lives normally through the winter as apterae and that sexuparae must be very rare and are so far unknown.

This winter, 1913–1914, I found apterous viviparous females again right through the winter, a weekly search being made, and they now and then produced living young.

Natural enemies.

In spite of this aphis having a very large number of natural enemies, they do not seem to have any effect upon it when weather conditions are favourable to it and unfavourable to the host plants. I have failed to find any parasites or predacious insects attacking it in winter when they might clear off the comparatively small numbers that then occur, nor do they appear until June or July, long after the aphides have done their worst harm.

Later in the year they are preyed upon by a number of natural enemies. The chief amongst these are several spiders, at least two species of Phalangidae or harvest men, and the adults of *Scymnus* sp. and its larvae to a small extent. That spiders and phalangids do enormous good there is no doubt at this time. But the most interesting enemy this aphis has that I have seen is the long eared bat. A tall tree in my garden was every night in July surrounded by these animals, hovering like a large moth at the tips and sides of the top branches, and clinging on to them. Wishing to know what they were so assiduously hunting for, I shot one and found it was full of hundreds of *Aphis abietina*, not only the alate females, but the apterae and nymphae that they must have taken from the needles.

I bred only two Chalcids. Several Syrphid larvae were active amongst them and *Adalia bipunctata*.

Treatment.

In plantations of course nothing can be done that would pay to do, but in nurseries and where any special trees we wish to save are attacked we can very easily destroy this pest. Paraffin jelly, nicotine and soft soap, quassia and soft soap, soft soap alone, lime sulphur wash and such patent washes as White's Abol, MacDougall's Summer Wash, and Cook's Tobacco Wash were tried. All with the exception of lime sulphur and soft soap alone killed great numbers, but the best results were obtained with Cook's Tobacco Wash, then with nicotine and soap and slightly below these came White's Abol, MacDougall's Summer Wash and paraffin jelly, then soft soap and quassia. Soft soap alone was not

found sufficiently penetrating to do much good. Lime sulphur at summer strength had no effect at all. The main thing is to give a very fine spray applied with force and to well wet the foliage. Winter treatment with strong paraffin jelly yielded excellent results and probably will prove to be the best method of treatment.

I have to thank Dr Henry for the information sent me from Ireland.

POLLINATION IN ORCHARDS.

By F. J. CHITTENDEN, F.L.S.

I AM venturing to bring the question of pollination in orchards before this Association, because, in the first place, it is one of extreme economic importance in the fruit-growing industry, since it touches one of the fundamental points for consideration in planning the planting of an orchard ; and, in the second place, the problems its phenomena raise include many of deep biological importance. Like so many of the questions the practical man has at present to solve by empirical methods, and which await scientific investigation, it touches more than one side of biological science.

Historical note. Swayne was the first, in 1823, to demonstrate by experiment that certain varieties of pears were self-sterile, *i.e.* required the intervention of pollen from another variety in order to cause fruit production. Peaches, old gardening literature shows, were thought to require pollen of other varieties, but experimental evidence seems lacking in regard to this fruit. The matter, although set out very clearly by Swayne, was apparently lost sight of until about 1890, when Waite re-discovered it for pears in America, and later found the same thing was true of apples. Considerable attention has been, and is being, devoted to the problem with these and other fruits in America, and to a less extent in Australia and other of our great fruit-producing colonies.

Our own experiments, begun at Chelmsford in 1902, confirmed Waite's observations, and clearly established the fact that a large proportion of our commonly grown varieties of apples and pears failed to set fruit unless pollen from some other variety was placed upon the ripe stigma. More recently Backhouse, and, later, Sherrard, has shown that our varieties of plums fall into two more or less distinct groups of self-sterile and self-fertile types. Cherries, peaches, nectarines, and probably grapes also, apparently show the same phenomena. Hooper's experiments at Wye are confirmatory. Some work has also been done by continental biologists upon the problem, but especially by Ewert in

Germany, and Müller Thirgau at Zurich, who have written several papers on "Parthenocarpie"—an expressive term which we owe to France.

Meaning of Terms "Self-sterile" and "Self-fertile." The terms "self-sterile" and "self-fertile" have been somewhat loosely applied in connection with this subject. In the strictest sense, self-sterility would mean that, although normal ovules were produced, without the intervention of pollen from another variety of the same kind, they would stop development at the egg-cell stage, and no *seeds* would be produced; conversely, in self-fertile varieties, the pollen from the same flower, or from a neighbouring flower on the same tree, would fertilize the egg-cell, and seeds would be produced.

We have purposely said "another variety," not "another plant," because the different trees of, say, "Cox's Orange Pippin" apple are all parts of the original tree which was raised at Colne in Middlesex, just as all the trees of "William's Bon Chretien" pear in all parts of the world (it is called "Bartlett" in America) are all parts of one, propagated by vegetative methods. The different trees of one variety are, although they have a certain individuality of their own, not individuals in the same sense as plants raised directly from seeds would usually be. The varieties of fruit trees are comparable with separately raised seedlings. All the trees of the apple "Blenheim Orange" are, for our purpose, but parts of one individual, all those of "King of the Pippins" of another, all those of "Ribston Pippin" of another, and so on.

This is the usual meaning of self-sterility in animals and in other plants, but with the fruit-grower the term has another significance. The important point for him is whether or not the fleshy envelope of the seed is matured—the seed itself concerns him not at all, and we find that a considerable number of varieties of apple and pear produce perfect fruits, except that they are seedless, when pollen of other varieties has no access to the stigmas. I have used the term "self-fruitful" for the production of fruit without the intervention of foreign pollen, whether seed is produced or not. Seedless apples and pears are by no means uncommon. They may be found any year, in any orchard, produced from summer flowers. They are common in such varieties as "Lord Derby" and "Golden Spire," when these varieties are not open to pollination by other varieties, for these are self-fruitful, though not self-fertile. They are normal in the pear "Ruyshe's Coreless" and in the apple "No-pip."

It is this form of fruit which is called parthenocarpic, but it is not yet clear whether pollination of any sort is necessary for the production of these seedless fruits. In cucumbers it certainly is not, for commercially grown cucumbers reach a large size without fertilization of any kind, and contain no fertile seeds. The histories of many seedless fruits, like the banana, and of the well-known seedless oranges, and other seedless fruits, seem never to have been thoroughly worked out, though something has been done with seedless grapes by Müller Thirgau. There may well be two types of parthenocarpy.

Further, it is not yet clear whether, in the case of the relatively few apples and pears which produce seed without the intervention of foreign pollen, the seed is produced parthenogenetically or not.

Parthenocarpic fruits are almost unknown in the plum and cherry.

Cause of Self-sterility. It is in only the rarest cases that apples or pears have unisexual flowers. Both ovules and pollen in some two hundred varieties of apples, and in the same number of pears, which we have examined, are apparently properly developed. The pollen is capable of germination in every variety, though the per cent. of germination varies greatly in different seasons. So far as our experiments have gone, it seems that the pollen of any variety of apple is capable of fertilizing the egg-cells of any other variety of apples, and similarly with pears. (Backhouse has shown this is not the case in plums and cherries.) Naturally, the enormous number of possible combinations has not yet been exhausted. The point needs further investigation, especially from the economic point of view, for some variety may be better fitted to induce fruit production in some other than are other varieties. There is sufficient evidence, however, to show that, while the pollen of one variety may be quite impotent when applied to the stigmas of flowers of the same variety, yet it is capable of fertilizing another variety and of inducing the production of viable seed. Extended microscopic examination of the apple flower has failed, so far, to reveal to us, either in its structure or in its development, anything to account for this remarkable state of things, both pollen and ovule appear normal in every way. We have been repaid in the rather time-consuming operations this examination has entailed by the discovery of one or two curious and possibly significant facts hitherto unrecorded, but these facts have no bearing upon the present question. We have, here, a very curious phenomenon, rather wide-spread in the vegetable kingdom, of incompatibility between the gametes of a hermaphrodite flower. Does such incompatibility exist among hermaphrodite animals? and

what can be its explanation ? A hypothesis which would fit all the facts has, so far, evaded us, nor have we been able to form a mental picture of what self-sterility means, and the whole question seems wrapped up with another of the deepest biological significance, viz. what is the real meaning of individuality ?

There is some evidence that this self-sterility is not absolute in, at least, some varieties. That is, a variety self-sterile here, may be self-fruitful somewhere in the range of its distribution, or in some seasons. It seems almost that, where the variety " does " best, it is more likely to be self-fruitful (whether self-sterile or not, the recorded observations do not make clear, though our own experiments tend to show that, *e.g.* in " Cox's Orange Pippin," in which self-sterility is the rule, when exceptions occur, seed is produced). This fact no doubt explains the contradictory evidence afforded by different observers on such a pear as " William's Bon Chretien," which produces fruit without foreign pollen in some places, not in others.

There is the further question as to whether vegetative vigour may not be a factor in the production of the seedless fruits already alluded to. It may be so, for we find vigorous trees of the pears " Conference " and " Durondeau " almost invariably very fruitful, and, where protected from foreign pollen, bearing seedless fruits, while, among apples, " Stirling Castle " very rarely fails.

It seems quite possible that the pollen of a self-fruitful variety such as these may have the function of stimulating the development of what may be called the vegetative part of the fruit, though it fails to effect fertilization. This is a very commonly observed phenomenon in the case of many orchids, even foreign bodies falling upon the stigma causing the production of fruits (of course, usually seedless). An interesting instance of the effect of stimulation of a rather novel character came to my notice not long since, and it was not an isolated instance. All the pears on a tree, except those attacked by the pear midge *Diplosis pyrivora*, fell very early, failing to swell, apparently owing to defective fertilization. Those attacked remained till the end of May, and, as is their wont, swelled very considerably. I commend this observation to the notice of our entomological members. The case of the absolute effect of the stimulus of egg-laying, or of the larval presence, is not quite conclusive, but it is certainly suggestive.

Some Economic Aspects of the Question. It is clear that a knowledge of varieties dependably self-fruitful would at once show what varieties might be planted in large blocks without fear of failure from this cause,

and this is an economical method of planting an orchard, since the same operations can be carried out simultaneously over a considerable and consecutive area. On the other hand, with self-sterile varieties, the knowledge of what varieties to interplant is important. It is quite certain that, until we have much more light on the causes of self-sterility, it will not be possible to give the authoritative advice for which the grower is entitled to look.

We are experimenting in the gardens of the Royal Horticultural Society, with the object of ascertaining what varieties of apple and pear are fertile *inter se*, and are carrying out other lines of work on the matter, and have just put up a large orchard house for extending our work, but, as we have indicated, observations in other localities upon particular points are of the utmost importance, in order that some of the questions at issue may be solved. The wish to bring this very important matter before the notice of those who may have the opportunity of carrying out some work upon it, is one of my objects in writing this note.

Certain points are, of course, clear, and the plainest is that varieties flowering at approximately the same time should be planted together. We have given, in the Journal of the Royal Horticultural Society, lists of varieties of apples and pears, in their relative orders of flowering, with the object of guiding the planter on this particular point, and we have there compared our own average dates of flowering with those of the same varieties in other parts of the world. These comparisons make it clear that approximately the same order of flowering is maintained by the different varieties all over the world, no matter what the climate may be, so that a list founded, upon the average for several years, drawn up in one locality, will prove a reliable guide in any other fruit-growing district.

Another point of economic importance lies in the relative size of fruits produced by the aid of foreign pollen and without it. They are, as a rule, larger when seeds are produced, and are reputed to be sweeter.

The Carrying of the Pollen. There remains another point of general interest: How is the pollen carried? The suspension of glass slips smeared with glycerine a few feet on the leeward side of blossoming apples and pears, has resulted in the capture of a very small amount of pollen, in marked contrast to the amount of pine pollen which we have so collected from pine trees as much as a quarter of a mile distant.

A large number of rather desultory observations have been published regarding the insects which effect inter-pollination in the apple and pear, and it is certain that insects are the chief agents. But some have claimed

for the hive bee a great preponderance of visits over those of other insects, and it would be a good thing to get the matter cleared up.

The record of captures at the flowers is of relatively little value, for that takes no note of the number of visits an individual insect may pay. I have watched a bumble bee, *Bombus terrestris*, for instance, pay 48 visits to different flowers (not all on one tree) in the course of ten minutes. Note ought also to be taken of the length of time over which the visits may extend. The bumble bee is out earlier by far than is the hive bee, and it goes to rest much later, but is the pollen in a fit state to be carried during all these hours ? The fishy scent of the pear, rather like that of hawthorn, no doubt attracts numbers of Diptera, and midges seem particularly partial to them.

Some one recently, too, pointed out the great importance of the hairy wild bees in effecting cross pollination in orchards, and, I am sure, it would be a productive piece of work if the investigation were taken up seriously. The Isle of Wight Bee Disease has practically exterminated the hive bee in many districts, and the cultivation of the ground in and round orchards has destroyed the nesting places of not a few of the insects that, in all probability, effected cross pollination in the past.

A CONTRIBUTION TO A KNOWLEDGE OF THE BELLADONNA LEAF-MINER, *PEGOMYIA HYOSCYAMI*, PANZ., ITS LIFE-HISTORY AND BIOLOGY[1].

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[1] Communicated by A. D. Imms, M.A., D.Sc.

1. *Introduction.*

The first record that we have of *Pegomyia hyoscyami* Panz. dates back over a century when Panzer described it in 1809 from Central Europe, including it in the genus *Musca*. Previous to this however Réaumur in the year 1737 gave an admirable account of the behaviour of the larva, with a few structural details, which he found mining the leaves of henbane, *Hyoscyamus niger*. He figured the larva, and drew attention to the resemblance that exists between it and the larva which he found mining in the leaves of the beet. No mention is made of the adult insect, a fact which Vallot noted in 1849, in dealing with the "Pegomyie de la jusquiame." This latter also observes that Réaumur's expectation that the larvae which mine the leaves of the pear would be identical with those found in the leaves of henbane failed in its realisation, for he showed that the adult insects belong to two different genera of Diptera.

This fly has been treated of by various authors and much confusion exists in the literature on the species, due to the fact that it has a fairly large number of food plants. This has led many authors astray, so that it has been described several times under various names, and in one or two cases the same author has described it under two different specific names. There does indeed seem to exist a distinct variety, namely that which attacks beet and mangolds, described first by Curtis in 1847. Much damage is done periodically to these crops both in this country and in Europe as well as in America. In fact so much so is this the case that it often constitutes itself a serious menace to their successful cultivation. In England and in Ireland Curtis and Ormerod recorded damage from various parts of the country, and Carpenter more recently has notified its ravages from Ireland, as also Farsky on the continent and Chittenden in America.

It was with the idea of verifying some points in the life-history of the species and also of unravelling the tangled skein of the nomenclature that I took the opportunity presented to me of rearing the species on *Atropa belladonna*, the Deadly Nightshade, which I believe to be the first record of its being bred from this plant. By means of facilities offered at Holmes Chapel Agricultural College Farm, I was enabled to compare it with the var. *betae* which was obtained from the mangold crop there, and I am also indebted to Professor Carpenter of the Royal College of Science for Ireland for several specimens kindly given to me. In addition I took the opportunity of making a comparison of the larval

characters of *P. hyoscyami* with those of *Pegomyia bicolor* Wied. and of *Pegomyia nigritarsis* Zett. The results of this comparison have been incorporated in this paper. The research was carried out in the Laboratories of the Department of Agricultural Entomology, Victoria University, and in the Experimental Laboratory, Fallowfield. It affords me great pleasure to express my gratitude to Professor S. J. Hickson for the various facilities readily granted to me, to Dr A. D. Imms for many useful suggestions made when the work was approaching completion and to Mr J. T. Wadsworth, who photographed the specimens for text-figures 2, 3 and 4.

2. *Synonymy of the Species and Nomenclature of the Genus.*

The *Katalog der Paläarktischen Dipteren* gives the following list of names which at one time or another were supposed to apply to valid species, and are included therein as synonyms of *P. hyoscyami.*

P. hyoscyami Panz., *P. atriplicis* Gour., *P. chenopodii* Rond., *P. conformis* Fall., *P. cunicularis* Rond., *P. effodiens* Rond., *P. egens* Meig., *P. exilis* Meig., *P. Gouraldi* R.-D., *P. haemorrhoa* Pand.

Var. *Pegomyia betae* Curt., *P. dissimilipes* Zett., *P. femoralis* Brischke, *P. spinacia* Holmgr.

In America, Lintner, in 1881, described the species under the name of *Pegomyia vicina.*

The generic name has not remained constant and the species has been included by various authors at various times in the genera *Musca* (Panzer, Fallen), *Anthomyia* (Meigen, Schiner, Rondani), *Anthomyza* (Zetterstedt), and *Chortophila* (Rondani). According to Stein (1905), Robineau-Desvoidy in his paper on the Myodaires (1830, 595) established the tribe Pegomyidae for a number of Muscidae which are distinguished from the Anthomyiidae by the more or less red colouration of the body, by the small squamae and because in the larval stage they subsist on the parenchyma of leaves. Rondani did not assume the genus *Pegomyia*, but from a consideration of the size of their squamae he disposed of the species in the genera *Anthomyia* and *Chortophila.* Meade in 1883 re-adopted the name *Pegomyia* including under it all Anthomyiids with naked, or at least pubescent antennary bristle, with the anal vein continued to the wing margin and with partly red colouration of the legs and abdomen. His species are classified into two sections, in the first of which there are four included, *P. betae, P. conformis, P. hyoscyami* and *P. haemorrhoum,* the last of Zetterstedt. The first

three of these are however synonyms for one and the same species. Pandellé (1907) considered *Pegomyia* as a sub-genus of *Anthomyia* giving the colour of the body as of sub-generic value, which is by no means satisfactory. Stein (1906), although admitting that the establishment of *Pegomyia* as a separate genus is quite artificial and untenable *stricto sensu*, yet adopts it in his scheme of classification. His reason for so doing is that the species included in the genus possess at least one plastic character in addition to colour, namely the quite regular absence of the cruciate bristles (Kreuzborster) in the female sex. In the few exceptions the presence of these bristles forms a very good specific character. In scrutinising the extent of the genus it is observed that Stein considered as belonging to *Pegomyia*, all Anthomyiids which have the antennary bristle naked, or at least slightly pubescent, eyes naked, always three dorso-central bristles behind the transverse suture, the anal vein continued to the margin of the wing and the tibiae yellow in at least the greater part.

3. *History of the Species.*

According to Westwood (1840) the larvae of *P. hyoscyami* are stated as devouring the parenchyma of the leaves of various plants, living between the two surfaces, but the author records no definite food plants. Zetterstedt in 1846 described the adult and quotes Wahlberg as having found several of the larvae in the parenchymatous tissue of the leaves of *Hyoscyamus niger* just before the plant flowered. Curtis in 1847 first recorded the var. *Anthomyia betae* as mining in the leaves of mangold-wurzel and quoted a short description of the larva. The author also described the adult male, the female being unknown to him. In his account the antennae and palpi are stated to be wholly black whereas the former have the basal segment more or less red and the latter have only the terminal segment black, the two basal segments being yellow as Meade later described. A doubt is expressed as to the extent of the damage caused by the maggots and a suggestion made that cattle eating the leaves containing them may be injuriously affected. In the following year (1848) Scholtz, in a paper on leaf-mining insects, has the following: "*Anth. betae* mihi (der *Anth. exilis* Meig., *versicolor* Meig., und *mitis* Fbr. verwandt) minirt nach meinen Beobachtungen in grössern Plätzen, die oft das ganze Blatt einnehmen, und zwar gesellig die Blätter von *Beta trigyna*." The author must have been unaware

that the name had been previously employed and the species described by Curtis.

In 1851, Goureau described the adult which he named *P. atriplicis* G. and called attention to the resemblance of the larvae to those found by Réaumur in the leaves of henbane. He reared his specimens from larvae which he found on the leaves of orache, *Atriplex hortensis*, and hence he named the fly "la Pegomyie de l'Arroche." The description of the larva is scanty, and that of the pupa, although brief, is the first record we have of this stage in the life-history of the species. Further he recorded and described a Braconid parasite which emerged from the puparium of the fly, and this he named *Alysia picta*. For the first time we meet with rather an interesting statement in this author's paper where he says that "la Pegomyie de l'Arroche" also attacks beetroot. This is a matter which will bear investigation as I am inclined to think that the species occurs in distinct "biologic species," each of which has its own food plant, and my experiments, although not by any means exhaustive, tend to support this fact. Guérin-Méneville in the same year (1851) described *P. atriplicis* R.-D. and states that in Goureau's collection this species is wrongly named *P. hyoscyami*, which he says is a distinct species. They are probably one and the same, as also the *P. Gouraldi* R.-D., which he also describes, seemingly from one immature specimen.

Nördlinger (1855) deals with the "Runkelfliege" (*Musca* (*Anth.*) *conformis* Fall.) and makes some very interesting observations on the life-history. He was the first to note the ornamental network on the chorion of the egg and he also attempted to determine the duration of the various stages in the development. Perhaps of most importance is his discovery of two broods of flies per year with perhaps a third in favourable climatic conditions. Comment is made on the backward growth of beet plants which are severely infested and on the difficulty of applying remedial measures. Taschenberg (1880) practically takes Nördlinger's description of the fly as well as his account of the life-history. He states that the development of the larva occupies a few weeks which, besides being rather indefinite, is inclined on the side of length. To compensate for damage caused by the pest he suggests that there should be no stinting in the amount of seed sown, a method which would have had little practical significance in combatting the enemy.

Schiner (1862) and Rondani (1864) give descriptions of *hyoscyami*, the latter employing the generic name *Chortophila*, and the only observation

that he makes of the larva is that he has on a few occasions seen it feeding between the two epiderms of the leaves of *Hyoscyamus niger* (henbane).

Kaltenbach (1874) records the larvae of *Anthomyia conformis* Mg. from *Chenopodium album* and *C. murale.* He also records the larvae of *A. betae* Scholtz from mangolds, those of *A. hyoscyami* Mg. and *A. nigritarsis* Zett. from *Hyoscyamus niger.* From henbane too he reared adults of *A. hyoscyami* R.-D., which he believes to be distinct from the *A. hyoscyami* of Meigen.

Farsky (1879) carried out some interesting experiments to determine the time occupied in the development of the egg, larva and pupa, but as the material was kept in glass-houses at a temperature much in excess of what would have normally prevailed outside, he recognised that the results were somewhat vitiated. For some reason or other which he could not explain he failed after several attempts to rear adults from first-brood larvae. With regard to the damage committed to beet crops, Farsky proved by direct experiment that those plants, the leaves of which had been mined, gave a markedly poorer yield when compared with that of unattacked plants. On an average he reckons that the beet plants which have been laid under toll by the pest have their polarisation affected adversely to the extent of two to four per cent. As preventive measures he advocates, like Nördlinger, an abundant sowing of seed with conditions kept fairly humid in the young stages of the plant's growth, and charcoal dust is said to be effective, but only to a small extent, in keeping the pest under control. Searching for the eggs on the leaves and their consequent destruction on being found is also of great utility.

Brischke (1880) in a most useful paper entitled "Die Blattminirer in Danzig's Umgebung," describes *Anthomyia femoralis* as a new species which he reared from *Chenopodium album*, but, except that the antennae are stated as being black, the description tallies with that of *hyoscyami*, with which it is agreed to be synonymous. The food plants of the polyphagous *hyoscyami* and its synonym *conformis* are also listed. Brischke attempts a rough classification of leaf-mining insects according to the mode of excavation of their galleries and the deposition of their excrement in the same.

Two Swedish entomologists, Holmgren (1880) and Tullgren (1905) have described the species from spinach, *Spinacia oleracea*, the former under the name of *Anthomyza spinaciae* ("Spenatflugen"), the latter employing Zetterstedt's name, *Anthomyia dissimilipes.* Besides spinach

Tullgren reared the fly from *Chenopodium album*. As remedial measures against the larvae, he advocates spraying the plants with a paraffin emulsion of the following composition; 10 litres of paraffin, ½ kilogram of soft-soap to 100 litres of water. Another method which he thinks might prove effective against the puparia in the soil is to spread the latter with soot, guano or superphosphate. Probably neither of these methods would prove very effective in combatting the pest.

In 1905 Professor Carpenter in Ireland reported the prevalence and ravages of *P. betae* in that country. In his account of the life-history he suggests the probability of there being four larval moults resulting in five stadia. As far as my own observations are concerned with *P. hyoscyami*, I think I may pretty safely say that there are not more than four stadia. The removal and burning of all affected leaves, as the author states, is an effective but laborious method, where large crops are involved, of temporarily minimising the ravages of the pest. Another and more practical method which he advises, consists in the application of a stimulating manure which, with a copious rain supply, would have the effect, at least in the young stage, of forcing the growth of the plant and strengthening it, the better to endure the attack of the maggots. As the author further observes, the affect on the yield of a mangold crop is most accentuated when the injury has been severe during the period when the young foliage has recently burst forth.

In America Chittenden (1903) deals briefly with the beet or spinach leaf-miner, *Pegomyia vicina* Lintn., and asserts that infestation of cultivated crops is often traceable to the negligent harbouring of weeds such as lambs-quarters which, the author says, fulfil the function of breeding-reserves on which the fly can always rely in times of need. As the fly is said to show a decided preference for spinach the author proposes its use as a trap crop in sugar-beet fields. Otherwise the methods of control are similar to those suggested by Professor Carpenter whose source of information is Chittenden's memoir.

4. *Distribution.*

This species is widely disseminated throughout Europe and is probably to be found wherever beet, spinach and mangolds are cultivated. Vassiliev (1913) records it from Russia and it is perhaps more prevalent in Northern (where these crops are more generally grown), than in Southern Europe Its ravages have been recorded from all over Great

Britain and Ireland and wherever mangolds are grown in this country it makes its presence felt.

In the collection of the British Museum (Natural History) there are specimens from the following localities in England :

W. Haddon, Rugby (W. Page); Newmarket, Walton-on-Naze, Slapton, S. Devon, Penzance (G. H. Verrall) ; Hastings (E. N. Bloomfield).

A better idea of its range is derived by consulting the reports of Miss Ormerod and Theobald, to which reference is made later.

In America its activities are practically confined to the New England States, and it has been recorded from Michigan. It also extends into Canada as Lochhead (1903) reports.

5. *Food Plants.*

The food plants of the species are distributed principally amongst the two orders Chenopodiaceae and Solanaceae. Brischke records it from a single example each of the Cruciferae, *Stellaria media*, and of the Polygonaceae, *Polygonum persicaria*. According to Goureau, Scholtz, Nördlinger, Kaltenbach, Brischke, Tullgren and Holmgren, the following are the host plants in Europe of *P. hyoscyami* and its synonyms.

Pegomyia hyoscyami Panz., Mg.
  Hyoscyamus niger (henbane)
Pegomyia betae Scholtz, Curtis
  Beta trigyna (beet), Hungary, Asia Minor
  Beta vulgaris (common beet)
  Beta vulgaris var. hybrida (mangold wurzel)
Pegomyia atriplicis Gour., Rob.-Desv.
  Atriplex hortensis (orache)
  Beta vulgaris (beet)
Pegomyia conformis, Mg., Fall., Nord., Zett.
  Stellaria media (chickweed)
  Chenopodium album (white goosefoot)
  Chenopodium murale (nettle-leaved goosefoot)
  Beta vulgaris (beet)
  Polygonum persicaria (spotted persicaria)
Pegomyia Gouraldi Rob.-Desv.
  Atriplex hortensis (orache)
Pegomyia femoralis Brischke
  Chenopodium album (white goosefoot)
Pegomyia dissimilipes Zett.
  Spinacia oleracea (spinach)
Pegomyia spinaciae Holmgr.
  Spinacia oleracea (spinach)

Jablonowski (1909) makes two significant statements with regard to the food habits of the larvae of *P. hyoscyami*. If the natural food plants should by any chance fail the larvae may complete their development on a diet consisting either of manure or humous matter, and also on decaying leaves of any kind. This is a point of much importance as, in cases of exigency, the species is always more or less ensured of a means of subsistence. Referring to the larvae the author says (p. 310) : "Gibt es für sie keine Wirtpflanzen mehr, so kann sie sich auch in diesem Falle helfen : findet sie kein ihr entsprechendes Blatt, so

lebt sie auch im gedüngten, oder im sehr humosen Boden (dies ist dann die *Anthomyia cunicularis* Rond)." Later (p. 313), he says: "Falls aber die eigenen Blätter der Rübe unzulanglich wären, finden sich wohl in der Nähe andere faulende Blätter, welche ihr ebenfalls zusagen. Die Fliegenmade bleibt in der einen, oder der anderen Weise doch immer am Leben und kann sich später in grösserer Anzahl vermehren."

6. *Description of the Leaf-Miner,* Pegomyia hyoscyami.

The adult (Pl. II, figs. 19, 20, 21, 22).

The following account has been borrowed and translated from Stein's paper on the genus *Pegomyia*, "Die mir bekannten europäischen Pegomyia-Arten," a very exhaustive and systematically arranged piece of work. The author points out that although enjoying a fairly wide distribution, the species cannot be designated a common one. The numerous synonyms applied to it are accounted for by the fact that the colour of the adult varies according to the life-history of the maggot, but in spite of this variation the plastic characters are so constant as to admit of the species being recognised with a fair amount of certainty. Stein distinguishes two varieties, *hyoscyami* Panz., the true species, light-coloured, and the darker form, *betae* Curt.

"The eyes, not very large, are almost equally broad above and below and are separated by a distinct stripe and the orbits. Frons projecting, cheeks small carinate, jowls rather broad, posterior aspect of the head convex below, bedusted all over silver-grey, on the cheeks close to the basal segment of the antennae a quite distinct, blackish, somewhat iridescent spot. Vertex as well as the median stripe generally blackish-red, also in some cases of a lighter shade, according to the age of the individual. Antennae incurving just below the middle of the eyes, shorter than the face, black, second segment more or less red, bristle naked, rather thickened at the base, palps thread-like, yellow, the terminal third segment black. Thorax, scutellum and abdomen in the lighter coloured form varying from pale to yellowish-grey, the former without perceptible striping; acrostichal bristles somewhat more closely set than the dorso-central, pre-alar small. The abdomen is sub-cylindrical, sometimes somewhat depressed and viewed obliquely from behind a small, pale brown median stripe is recognisable; the rather swollen hypopygium as well as the ventral lamellae (belly) is

often of a reddish colour, rarely the entire abdomen is of a brick red colour. Legs yellow, anterior femora with a more or less distinct, longitudinal streak, tarsi black, pulvilli and claws rather elongate. The investment of bristles does not present any special characteristic, only it might be noted that, of the bristles on the outer side of the posterior tibia, the one beneath is usually quite long. Wings pale yellowish, without costal spine, third and fourth longitudinal veins parallel, posterior cross vein steep and straight, the equally-sized squamae whitish-yellow, halteres yellow.

In the darker form the thorax and abdomen are of a more brownish colour and on the former there is seen posteriorly the faint trace of three somewhat dark longitudinal stripes. The abdomen as viewed from behind is thickly bedusted, pale brown and a fine dark dorsal line is relatively quite distinctly recognised ; it is often interrupted at the posterior margin of the segments. The rather strikingly spherical hypopygium is bedusted just like the abdomen, sometimes overspread reddish, the ventral lamellae reddish. The colour of the legs varies : either only the anterior femora brown or also the middle and posterior femora completely or at least on their upper surface, although sometimes very indistinct.

The eyes of the female are more roundish, the broad frontal stripe reddish-yellow, sometimes somewhat obscured, the entire head either pale brown or reddish, palpi generally thickened at the extremity, club-shaped. Thorax grey or brownish-grey with the trace of a fine median stripe ; sternopleural bristles 1·2, the lower posterior but considerably smaller than the upper, often only hair-like. In the matter of colour, the abdomen again very variable, either pale brown or brick red, sometimes a dusky red with the posterior margins of the segments a pale brick red. But in all cases there is faintly seen, when looked at quite obliquely from behind, a fine brownish or reddish longitudinal line. The legs are rarely entirely yellow, generally the anterior femora with a more or less evident longitudinal streak."

Length 5·8–6 mm. Wing 5·5 mm.

The egg (Pl. I, fig. 1).

The eggs are pure white, elongate oval, 0·87 mm. long × 0·31 mm. ; surface not glistening, with a delicate sculpturing or pattern of irregular hexagonal areas on that side of the chorion distal from the leaf ; surface attached to the leaf, plain ; micropyle in a small depression at the apex.

The larva (Pl. I, fig. 2).

Larva, newly hatched, about 1·0 mm. in length, almost transparent, with mouth apparatus, tracheae and alimentary canal distinctly visible through the cuticle. Anal spiracles sessile with two slits apparently communicating, shaped like a semi-inverted ω, thus ϵ. Fleshy tubercles on the ultimate segment not very distinct. Anterior thoracic spiracles absent. Immediately before the first ecdysis the larva has increased its length to 1·6 mm.

The second instar larva (Pl. I, fig. 6), smooth, with a pair of prothoracic spiracles, one on each side of the post-cephalic segment and each divided into seven lobes. Posterior stigmata situated on the oblique dorsal position of the ultimate segment with two slits (Pl. I, fig. 7, *p.sp.*) just as in the first-stage larva, but constriction between the two now more accentuated, slightly elevated. Paired tubercles of the last segment are four in number (Pl. I. fig. 7), with rather a large but inconspicuous pair of flat adanal lobes (*a.l.*). On completion of the second stadium, the larva has almost doubled its size, now measuring 2·8–3 mm. in length. Following another ecdysis, the larva enters the third stadium when, except for size, it resembles in all respects the fully mature larva. Length 6 mm.

The full grown larva (Pl. I, fig. 2) averages about 7·5 mm. long and 1·8 mm. broad, with thirteen segments of which twelve are evident, of a dull yellowish colour, much wrinkled. On the cephalic segment immediately posterior to the mouth hooklets are situated the minute two-jointed antennae (Pl. I, fig. 4, *a.*), and slightly posterior to these again and placed somewhat nearer to each other, is a pair of sensory spots (*s.p.*). The prothoracic spiracles (figs. 2, 4, *pt.sp.*) quite distinct, with the number of lobes increased to eight. Definite areas on each segment bear minute, closely-set locomotory spines, arranged lineally in rows; on the first two segments posterior to the head the spinous areas are not so definite, but these bear anteriorly three or four regular rows of spines encircling the segments. Ultimate segment has the posterior aspect divided into two distinct areas, a dorsal oblique and a ventral truncated, bearing in all seven pairs of small tubercles (Pl. I, fig. 3) arranged as in figure. The pair lying immediately below the spiracles in the stigmatic field are slightly internal to the circumference of the circle formed by the others. Posterior spiracles (*p.sp.*) sub-sessile,

with three apertures clearly delimited, of which the two placed more dorsally are about half as far apart as the median and ventral.

There would appear to be much individual variation both in the size and structure of the mature larva. For instance Farsky (p. 111) states the size to be 7 mm. long and 1·7 mm. thick, and Professor Carpenter (p. 290) gives the length as being 8–10 mm. The latter also states that the prothoracic spiracles have eight to ten branches whereas I have only been able to observe eight in the full grown larvae. A possible explanation of such variations as being an expression of differences in the nature of the host plants, readily presents itself to our minds, and while Farsky's larvae were reared from beet leaves and Carpenter's from the leaves of mangolds, mine fed on the leaves of belladonna. It may be that we get distinct "biologic species" of flies according to the food plants which they patronise.

In a note which I have from Professor Carpenter, dated October 12th, 1912, the writer realises the probability of variation in definite species of dipterous maggots, but states also an interesting case of convergence where, if one takes a large series of larvae of *Lucilia Caesar* and *Calliphora erythrocephala*, distinctions which apparently hold good amongst a small number lose their value. His attention was drawn to this fact by Dr R. Stewart MacDougall.

The puparium (Pl. I, fig. 13).

Puparium measures 4·8–5 mm. in length, greatest breadth about 1·4–1·5 mm. Shape rectangular oval, narrowing sharply both anteriorly and posteriorly, sides slightly sinuate in outline, but not so markedly as in the puparium of *P. bicolor* (fig. 14). The rounded contour of the last segment interrupted by the slightly projecting posterior spiracles. Anterior spiracles less prominent with a lateral outward inclination. Scarcely a trace of the posterior tubercles of the larva. Segments distinct, demarcated by narrow striate bands of lineally and serially arranged spines, characteristic of the larval cuticle, as shown in the figure. The whole puparium as if lightly scarred or wrinkled, a condition due to the general contraction that occurred in the transformation from the larva. Colour at first pale ochreous yellow, gradually deepening through shades of red, reddish-brown to dark brown and brownish-black.

7. *Copulation, Oviposition and Egg Period.*

The Anthomyiidae are very restless active flies, and in captivity they seem to be endowed with such exuberance that they rarely become accustomed to the narrow confines of a wire-gauze breeding cage, such as was used throughout in the experimental rearing of *P. hyoscyami*. In many ways these roomy cages, as manufactured by Voss, commend themselves for observational purposes, built as they are of stout sheet iron, with sides of wire gauze, back wall and sloping roof of iron and with a glass panel front. On one side there is a hinged door and basally a detachable, well-fitting tray of zinc for containing soil, into which the fully mature larva of the species in question burrows previous to pupating. A potted plant of belladonna (the host plant of *P. hyoscyami*) was introduced into the cage and periodically watered to maintain its freshness and ensure its growth. The stout heavy basal part of the cage may be detached from the upper, lighter portion by the removal of two small, bent, iron rods, one on each side, fitting closely into hollow projecting iron cylinders placed alternately on the upper edge of the basal and the lower edge of the upper part. When in position these rods fix the two parts of the cage firmly together.

Copulation takes place after the lapse of a number of days from the time of exit of the female from the pupa case. This interval is determined by one or more factors, such as the constitution of the female, the kind of nutrition and the amount of food, the time of year, and the prevailing weather conditions. For instance in the breeding cages kept in the insectary which had free access to daylight and where the conditions were, as nearly as possible, similar to those in the open, the flies were never observed to copulate when the sky was overclouded. Indeed, in the summer and autumn of 1912, owing to some reason or other, copulation never occurred in the cages and consequently no eggs were laid. Never yet has it been my good fortune to observe the act of pairing outside, but on Aug. 26th, 1913, the behaviour of the flies in this respect was noted for the first time and the accompanying sketch (Text-fig. 1) drawn from life.

As represented in the figure, the male stands above the female with its fore tarsi applied to the thorax and resting on the shoulders of the wings which are kept divaricate. The middle tarsi of the male embrace laterally the fifth abdominal segment of the female, whilst the hind tarsi encircle the extremity of the latter's abdomen. The femora and tibiae

of the middle and hind legs of the male are hunched up, the femora ascending backwardly and the tibiae descending forwardly making a sharply acute angle with the femora. The head of the male extends forward above the level of the scutellum. The ventral side of the male's thorax rests upon the dorsal region of the female's abdomen, and the concave ventral surface of the male abdomen arches round the convex dorsal surface of the female's in such a manner that the hypopygium (the modified ninth abdominal segment) of the male with its claspers and intromittent organ extends under the extremity of the female abdomen and is closely applied to the latter for purposes of coition.

The act of pairing continues for about half an hour and even longer, and, if disturbed, the female endeavours to liberate itself by pressing

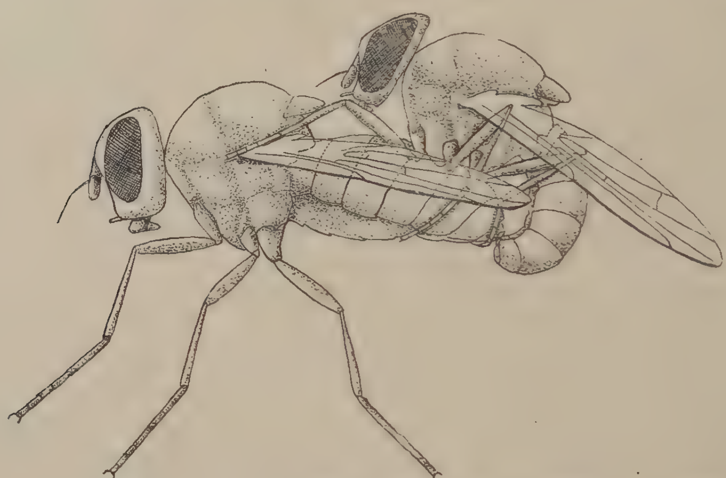


Fig. 1. *Pegomyia hyoscyami* in copulation. The investing bristles are omitted. ×12.

with its posterior tarsi against the tarsi of the male, in its attempt to loosen them.

Martelli (1908) in his paper " Altre Notizie Dietologiche della Mosca delle Olive," p. 93, describes copulation in *Dacus oleae*. The position adopted by the male of this species is quite different from that of *P. hyoscyami* owing to the female's having a long, exserted ovipositor, which is general in the Trypetidae. In this case the anterior tarsi of the male embrace laterally the first abdominal segment of the female, while the others rest upon the ground.

Oviposition does not always take place immediately after copulation, and indeed all evidence points to the necessity of an interval of one or

more days. The female lays the eggs (Text-fig. 2) superficially on the under side of the leaf (only once have I observed the eggs on the upper surface), generally in neat, parallel rows, the eggs of any one row being closely applied to each other laterally and seemingly held together by a kind of cement which also serves to attach the eggs to the leaf surface. A good idea of what is meant will be obtained from the figure. The number of eggs in any one row as well as the number forming an egg-group varies. All sorts of combinations may be got. The number may be as low as one or two and there may be as many as fifteen or twenty, and even more. On the same leaf, apparently depending on

Fig. 2. Eggs of *Pegomyia hyoscyami* on under surface of a belladonna leaf. ×9.

its size, there is often more than one group of eggs and rare cases of three or four are recorded. The flies seem to show a preference for the leaves of the top shoots, but later on in the season the radical leaves become quite as badly attacked.

The eggs hatch in from four to five days, but as long an interval as five to six days has been recorded. Farsky (p. 109) states the period to be six to eight days in the case of the synonym, *P. conformis*, and

Chittenden (p. 51), quoting Howard, gives it as three to four days in the case of the synonym *P. vicina.* The time will vary according to the weather conditions and temperature, and to the degree of exposure of the eggs on the various leaves. In the laboratory where a temperature of 70° F. was maintained, the eggs hatched usually after the short interval of three days.

In order to get an approximately accurate idea of the duration of the egg period, the belladonna host plant was kept under close observation in the open. As soon as a leaf was noted with eggs newly deposited, a tag-label bearing the date was attached to the stem immediately below the leaf petiole and numbered. From time to time the leaves thus marked were closely examined. A fairly exact idea was thus obtained of the time occupied in the development of the embryo within the egg. Some of the results are appended in Table I :

TABLE I. Pegomyia hyoscyami *and its oviposition.*

Number of Experiment	Date of Oviposition	Number of Eggs in a Group	Date of Hatching of First Egg	Number of Days
1	24th June	4	29th June	5
2	24th ,,	6	30th ,,	6
3	25th ,,	12	1st July	6
4	26th ,,	8	30th June	4
5	27th ,,	11	3rd July	6
6	28th ,,	14	4th ,,	6
7	28th ,,	13	3rd ,,	5
8	28th ,,	9	3rd ,,	5
9	29th ,,	8	4th ,,	5
10	30th ,,	7	4th ,,	4

It must be observed that the larvae generally hatched in the cool of the evening, and in a few cases the emergence of the larva occurred during the night. In these latter the time could only be guessed at, but with quite a close approximation to the truth since an indication would generally be got of the time that the larva had abandoned the egg, from the progress which it had made with its gallery beneath the epiderm. The eggs of any one group do not hatch synchronously, but the variation in time is often only one of minutes. As long as twenty-four hours between the hatching of the first and last eggs have been noted. Later in the season, towards the end of September, a single case where the eggs took eight days to hatch was recorded.

The number of eggs which any one individual will deposit cannot

be definitely stated, but a reference to my notes reveals the case of one female which laid first eleven eggs and then proceeded to deposit two more groups of twelve and nine. The probability is that even then she had not finished. Perhaps forty would be a very low estimate. In an examination of a fertilised female about one hundred and forty ova, of which twenty-two were ready for oviposition, were discovered in the egg-tubes and uterus.

Habits of larva, duration of the various larval stadia, pupal period.

The behaviour of the larva within the epiderm of the leaf has been fully dealt with by Farsky (pp. 109–110) in the case of *P. conformis* mining beet leaves and what is said there holds good for the larvae of *P. hyoscyami* in belladonna leaves. Réaumur has also given a detailed description for the larvae mining in the leaves of *Hyoscyamus niger*, and my observations practically agree with theirs.

The young larva makes its exit from the egg by a small circular aperture at the micropylar end. Operations on the leaf epiderm are immediately commenced with a view to an entrance to the underlying mesophyll layers, but at this time its actions are not characterised by excessive energy. The egg-shell collapses when the larva has abandoned it, and a small quantity of frass, the excrement of the tiny maggot as it burrows into the leaf, is left behind. It would appear that an ecdysis occurs on the exit of the embryo from the egg. In all cases where evacuated eggs were examined, a very thin, transparent, delicate membrane was persistently found adhering to the internal walls of the chorion. The whole process of the larval emergence is a progressive one. The larva, by eating its way into the parenchyma, makes a gallery for itself, increases its size, and by bodily extension, rends the egg-shell longitudinally and ventrally. The migration from the egg to the parenchyma is stated by Farsky (p. 109) to occupy a whole day, if the weather conditions are favourable; if adverse, the operation occupies two to three days, whilst excessive moisture induces abortion.

Where a large number of eggs are present on one leaf, it is often impossible for all the emerging larvae to find subsistence thereon, and consequently many are sacrificed. On several occasions it was observed that when two or three batches of eggs were deposited on a single leaf, only a few larvae succeeded in attaining maturity. Should a comparatively long interval elapse between the times of emergence of the larvae from the different egg-bundles, those which hatch earliest stand

the best chance of completing their development. If, in the course of their activities, they undermine the mesophyll layers beneath a bundle of unhatched eggs, the larvae issuing from the latter do not attempt to enter the leaf where the epiderm has been loosened, but they search about for a part that is fresh and untouched. Often they die before they succeed in fulfilling their mission, and, indeed, sometimes the eggs do not hatch at all. The exact reason for this it is not easy to find. Perhaps it may be that they merely undergo desiccation owing to the discontinuance of the respiratory functions of the injured part of the leaf. The incurrent and excurrent streaming of moisture-bearing gases through the leaf-stomata, which would, in the natural course of events, maintain an atmosphere sufficiently humid for the successful development of the embryo in the egg is totally checked, with fatal results.

No definite information has been previously given of the duration of the various larval stages of which there are undoubtedly three, and the statements also of the different authors of the length of the complete larval and pupal stages are apparently in disagreement. But this seeming inconsistency is quite comprehensible when one considers that the times may vary in multi-brooded species depending on the season, according as it is the first, second or third brood, and further because of the climatological conditions which prevail in different countries as well as in different districts of the same country.

As indicated previously in the description of the larva, there are at least two moults and three distinct stadia. Carpenter (p. 290) suggests the probability of there being four moults, but I have not been able to verify this additional one which he assumes as intervening in the last larval stadium. During the month of June the larva completed its development in about ten days. Later in the year, during September, as many as twelve days were required. Where incidental circumstances are favourable, the times of the various larval stages are approximately twenty-four hours for the first, forty-eight hours for the second and seven days for the third.

It is interesting to note the time occupied by the larvae of the different stages in making an entrance into a fresh leaf when placed upon its surface. In some cases they get to work rapidly. Often they keep wandering restlessly here and there. The following are three authenticated cases, the facts of which were noted on June 23rd.

(1) Three larvae recently emerged were removed to a fresh leaf. After a few sluggish efforts to pierce the epiderm, which occupied an hour, they gave up the attempt. Even when a tiny puncture was

made for them with the point of a needle they achieved no progress and finally died in about an hour and a half.

(2) A larva in its second stage was similarly treated. After moving about actively for about a quarter of an hour, it seemed to find a spot to its liking. Working vigorously it first made a small slit in the epiderm which it enlarged to a circular aperture by an unflagging series of to and fro, semi-rotatory movements of its mouth hooks. In two hours and twenty minutes it had disappeared completely from view in the gallery which it had eaten out.

(3) A larva of the third stadium, recently moulted, accomplished the same performance in the comparatively short space of twenty-five minutes.

The pupal stage extends over a period of about two or three weeks, and sometimes longer. Nördlinger (1885) believes the pupal stage occupies fourteen days, whilst Taschenberg (1880) gives as low an estimate as ten days, which is in accord with the ten to twelve days cited by Jablonowski (1905). The insects hibernate in the soil as puparia. Several larvae, collected during October, assumed the resting condition on the 20th of this month, and from one of the puparia which were kept amongst damp sand in a cool-house, an adult emerged on May 24th of the following year, representing the elapse of one hundred and fourteen days.

The adult period, length of life-cycle.

When the fly is ready to emerge it bursts open the retaining pupa-case anteriorly by means of the pressure of the exserted ptilinum and makes its exit through the resulting T-shaped cleavage. The animal does not at once assume its final, natural colour. The thorax is pale, cinereous, whilst the legs and abdomen are pale yellowish. Having finally rid itself of the puparium, the imago remains resting for a time during which the ptilinum is periodically inflated. This action together with a peristaltic movement of the abdomen, is associated with an apparent growth in size of the fly and also with the expansion of the wings hitherto neatly folded up and closely applied to the body. The wings take about three minutes to expand completely, the extremities unfolding first. All the time the colour is becoming darker.

There is then a period of apparent rest when the various regions of the body assume their normal shape, and the cuticle hardens. The wings are slightly raised and become more transparent. The frontal

region of the head loses its flexibility, and becomes more or less rounded. There is then a period of contraction when the fly remains motionless. The abdomen shortens gradually until it has attained its natural size, whilst the head and thorax also become visibly smaller. By this time all the parts have assumed their fundamental colours. The complete operation occupies about an hour.

The adults live for about two weeks but, in confinement, when fed on a solution of sugar, they will live for as long as three weeks.

From a consideration of the foregoing remarks on the life-history of *P. hyoscyami*, a fairly definite idea may be got of the time that elapses for the various stages of development in the north of England during midsummer :

		DAYS
Time intervening between the issue of the adult and oviposition		4
Egg period		5
Larval period		
First stadium	24 hours	
Second ,, ...	48 hours	10
Third ,, ...	7 days	
Pupal period		17
Average time for one brood		36

There are at least three broods per annum, but there is a good deal of overlapping of the various stages owing to differences in the times of emergence so that eggs, larvae, pupae and adults are all found to occur simultaneously from June to September.

8. *The Buccal-Pharyngeal Apparatus.*

The complete masticating apparatus of the mature larva of *P. hyoscyami* (Pl. I, fig. 15) consists of a number of paired sclerites, the members of each side articulating with one another to form a united whole. In the younger larval stages the form of the apparatus is essentially similar to that of the fully-developed larva, the difference being one of degree and not of kind. Each moult sees a strengthening of the chitinous structure.

The strong tooth-like hooks which are seen projecting when the larva is feeding are the mandibular sclerites (*md.s.*) provided ventro-laterally with four small teeth and with a blunted dentate process

ventro-posteriorly. Basally each is perforated by a tiny pore. The dentate sclerites which articulate ventrally with the posterior halves of the mandibular sclerites of the larva of *Anthomyia radicum*, as Hewitt figures (Pl. II, fig. 7, *d.s.*), are here absent. Articulating posteriorly with the mandibular sclerites are the hypostomal sclerites (*h.s.*) united to each other by a slender rod, not evident in a lateral view. Each individual of this pair somewhat resembles a short dirk. From the angle formed by the handle and the blade there proceeds a delicate, slender rod (*i.s.*) which articulates with the broad, ventral, posterior process of the mandibular sclerite. The proximal extremities of the two hypostomal sclerites articulate, one on each side, with the distal ends of the cephalo-pharyngeal sclerites (*c.p.s.*) which have each a slight anterior, ventral, ploughshare-like continuation joining on to the hypostomal sclerite of its side. The cephalo-pharyngeal sclerites are broadly and deeply embayed posteriorly, thus forming a dorsal (*d.p.*) and a stout ventral process (*v.p.*). The latter is provided posteriorly with a dorsally directed blunt process. The dorsal arm of the cephalo-pharyngeal sclerite is itself bifurcate, so that a slender ventral process directed posteriorly underlies the broader dorsal process. Finally the perforate sclerite (*pf.s.*) situated dorso-anteriorly between the cephalo-pharyngeal sclerites, serves to unite them. In the figure it would appear to be quite detached. This displacement is caused by the pressure of the cover-slip on the mounted preparation from which the drawing was made. Midway between the ventral arms of the cephalo-pharyngeal sclerites there is situated a carinate sclerite of very slender proportions.

In Carpenter's figure of the mouth apparatus of the mature larva the cephalo-pharyngeal sclerite is represented as having quite a pronounced rectangular continuation anteriorly, where it articulates with the hypostomal sclerite. This gives one the impression of a foreshortening of the latter. In reality the suture is placed rather more posteriorly and the apparent continuation of the cephalo-pharyngeal sclerite belongs to the hypostomal.

9. *Comparison with* Pegomyia bicolor *Wied. and* Pegomyia nigritarsis *Zett.*

The two allied species *P. bicolor* and *P. nigritarsis* mine the leaves of *Rumex obtusifolius* and *Rumex crispus* in their larval stages, and their life-histories are practically identical and concurrent with that of *P. hyoscyami*. As imagos all three species have the same general facies

so that it is of interest to find that the larvae can be quite easily distinguished as also the puparia. It is almost impossible to find any distinguishing feature in the eggs of the three species. In each case the chorion has the same hexagonal pattern, but generally the sculpturing is more delicate on the eggs of *hyoscyami* (Pl. I, fig. 1) than on those of the other two, *bicolor* and *nigritarsis*. We realise however that this character is insignificant and unimportant, inclined as it is to much variation.

The following table is a *résumé* of the distinctive characters of the larvae, by which the three species may be separated and recognised in the larval condition :

Larval Character	*P. hyoscyami*	*P. bicolor*	*P. nigritarsis*
Integument	Wrinkled No post-cephalic ventral tubercle (" foot ")	Smooth, tough Post-cephalic ventral tubercle present (fig. 8, *a.p.*)	Smooth Absent
Colour	Dull, yellowish-white	Yellowish, iridescent	Dull white
Length	8 mm.	10 mm.	9·5 mm.
Anterior spiracles ..	8 lobes (Pl. I, fig. 5) Palmate	25–30 lobes (Pl. I, fig. 11) Ellipsoidal	16–25 lobes Semi-ellipsoidal
Posterior spiracles ..	Sub-sessile (Pl. I, fig. 3, *p.sp.*) 3 apertures broadly oval, equidistant, of equal size (Pl. I, fig. 3)	Porrect, prominent stigmatic projection, 2-segmented (Pl. I, figs. 8, 9, *p.sp.*) 3 apertures, elongate oval, acuminate; equidistant (Pl. I, fig. 9)	Slightly projecting (Pl. I, fig. 12, *p.sp.*) 3 apertures, elongate oval, the largest dorsal, separate; twice the distance between the dorsal and the median as between the median and the ventral (Pl. I, fig. 12)
Tubercles of Ultimate Segment	7 pairs (Pl. I, fig. 3)	3 pairs—adanal lobes (Pl. I, fig. 9)	6 pairs, of which 2*a* and 3*a* placed posteriorly (Pl.I,fig.12)
Antennae and Sense-organs	Sense-organs not so widely separate as the antennae (Pl. I, fig. 4)	Sense-organs almost adjacent, antennae separate	Sense-organs have same distance apart as antennae; situated nearer the antennae than is the case in *bicolor*

Nathan Banks (1912) describes and figures only twelve lobes to the prothoracic spiracles of *bicolor*, but careful examination of *bona-fide* specimens has always shown the presence of at least twenty-five lobes.

As the puparium, which represents the shrunk larval integument, retains the external characters of the larva in greater or less degree, though not always so prominent, the same distinctions thus hold good for the resting, as for the active, larval stage.

The mouth apparatus is of the same general formation in all three species, with the component sclerites practically similar in shape. They only differ in quite small details almost negligible for purposes of classification. A comparison of the cephalo-pharyngeal sclerites of *hyoscyami* and *bicolor* shows that the upper subtended process of the dorsal arm is relatively broader in the latter species (Pl. I, figs. 15, 16 and 17, *d.p.*). In *bicolor* the angle formed by the hypostomal and interstitial sclerites is more acute than is the case in *hyoscyami*, which is 45°. Further, the mandibular sclerites of *bicolor* bear dorso-posteriorly a small, backward-curving denticular process (Pl. I, fig. 17, *d.p.*), absent in those of *hyoscyami*, which aids in forming a concavity for the articulation of the distal extremities of the hypostomal sclerites. Again the teeth or denticles borne by the mandibular sclerites of *hyoscyami* arise more laterally than those of *bicolor*. The relation of parts is practically the same in *bicolor* and *nigritarsis*.

These generalisations have been made on the evidence of numerous specimens carefully examined, but I quite realise that the characters may not be absolutely stable. In some cases as will be seen from the foregoing remarks, the distinction of the species has a negative basis, depending on the presence of some detail in one species which is absent in another. This is often very useful for classificatory purposes, but either the specimens must be examined fresh or precautions taken that those examined have been well preserved.

10. *Remedies in England.*

Miss Ormerod collected much valuable information about the infestations of the mangold fly, which was incorporated in her reports of the years 1880–95. Severe attacks were recorded periodically from all parts of England, Ireland and Wales, from Cumberland and Westmorland in the north, where the species was first recognised about 1876 as a serious pest of mangolds in this country, to Devon and Cornwall in the south-west. The years 1880 and 1891 were notable for the great amount of damage done to this crop which was in many cases practically sacrificed to the ravages of the leaf-mining maggot. The same author also noted that the incidence of the fly was generally associated with the use of farmyard manure as a crop stimulant, especially when

applied in the spring, immediately previous to the sowing of the seed. Autumn manuring, as soon after the harvest as possible, is therefore advised, a course which Jablonowski (1909) also recommended in the cultivation of the beet. The manure is thus given a chance to decay and sink well into the soil during the winter months with the result that the fly is not attracted by it to the same extent as it would be by fresh dung.

The greatest and most lasting damage is usually committed by the mangold maggot at the seedling stages of the plants soon after they have been singled out. Thus a system of manuring which forces on the growth of the crop beyond this susceptible period, proves of much advantage in staving off ultimate disaster. To accomplish this Miss Ormerod found that the application of sodium nitrate in the proportion of about two-hundredweight to the acre produced desirable results. The only drawback is that, unless there be sufficient rain to wash the fertiliser down to the roots, its value as a stimulating agent is vastly reduced and almost negligible. Dressings of salt, potash and superphosphate introduced to the soil along with the seed have often proved beneficial. Where clean culture is practised and where the crop is grown in situations favourable to growth the loss incurred from the ravages of the maggot is not very appreciable. When neglected, the crop simply perishes from exhaustion in consequence of the leaves being killed off by the maggots more rapidly than the plant can replace them.

Spraying the infected crops with paraffin emulsion is another method which was brought to Miss Ormerod's notice (1885, p. 68) as an efficient remedy. The insecticide is made up in the proportions of 8 parts of water to 1 part of soft soap with $4\frac{1}{2}$ parts of paraffin added to the first two of these ingredients which have been previously mixed and boiled. A homogeneous mixture is thus obtained, and 1 part of the emulsion combined with 4 parts of water is said to prove quite effective in killing off the maggot.

Theobald also deals with the occurrence of the fly in this country in his reports 1909–11, and the same methods of combatting its attacks are recommended as those given by Miss Ormerod. This author also states that deep ploughing after an attack of the maggot will bury the puparia in the soil, thus rendering the emergence of the fly to the surface a difficult one. But I should imagine that where the soil is inclined to be heavy, forming clods instead of a fine tilth, the adults will generally succeed in making their way up, so that this method would only prove of utility in the case of light soils.

In carrying out experiments with the maggot which mines in the leaves of the belladonna, I found that an emulsion consisting of nicotine, paraffin and soft soap with water would at least check virulent attacks, and, if applied to the plants early in the season, it proved an excellent preventive against the fly ovipositing. The fully developed larvae did not seem to experience much inconvenience from contact with the insecticide, which is prepared as follows: to four parts of soft soap two pints of paraffin are added, and the mixture brought to the boiling

Fig. 3. Belladona plant used in breeding experiments of *Pegomyia hyoscyami*. Appearance after attack.

point. A small quantity of boiling water is then stirred in, and the whole then well mixed until a good emulsion is obtained. Four ounces of 95 % pure nicotine are then added. After thoroughly mixing the volume is increased to 100 gallons by the addition of more water. If poured into a drum and kept well corked the mixture can be stored and used at any time. The insecticide should be administered as a fine spray by means of a nozzle of the improved Vermorel or other makes, care being taken that both the upper and under surfaces of the leaves

are drenched. It penetrates the epiderm where the latter has become detached from the parenchyma and is most effective against the larvae of the younger stages. The best results are achieved if the nicotine-paraffin-emulsion is delivered to the plants just before the flies may be expected to oviposit as it wards off the adults. Frequent sprayings should be made in order to keep the pest under control. The cost works out at about 3*s*. 9*d*. per 100 gallons of the mixture.

11. *Natural Enemies of the Belladonna Leaf-Miner.*

Three species of parasitic Hymenoptera were reared from the puparia of *hyoscyami*. Of these two are Braconids belonging to the genus *Opius* and one of them is *Opius nitidulator* Nees ; Pl. I, fig. 23 represents

Fig. 4. *Opius nitidulator* Nees. Parasite of *Pegomyia hyoscyami*. Also parasitised puparia of *Pegomyia* showing the ragged edges where the parasites have emerged.

the fully developed larva of the latter dissected out from the puparium of its host. The third is a Proctotrypid, probably a hyperparasite of one or other of the two species of *Opius*, or perhaps of both. It was comparatively rare. The percentage of parasitism is rather high and, as the season advances, increases in intensity until the beginning of September, when it suffers a diminution.

Examination of larvae and puparia collected towards the end of this month and during October revealed very few parasites, a fact which may be associated with the diminution in temperature experienced in the autumn. This is borne out by the fact that the parasites are not so

prevalent when the first brood of the leaf-miner is on the wing as during the occurrence of the two subsequent generations, showing that the hibernating pupae had not been heavily attacked.

Continued spells of cool, damp weather are believed to have the effect of reducing the number of parasites, but this was certainly not very marked during the wet summer of 1912. The percentage was only slightly less than that of the following year, when more favourable conditions prevailed. This fact will be seen by consulting Table II, which shows the number of parasites that emerged from infested leaves collected in the field and kept either in breeding jars or cages in the laboratory:

Table II. Pegomyia hyoscyami *and its parasites at Fallowfield, Manchester, in* 1912 *and* 1913.

Month leaves were collected	Locality	Experiment No.	No. of *Pegomyia* emerged	No. of parasites emerged	% of parasites to total insects emerging
July 1912	Fallowfield	1	86	18	17
Aug. ,,	,,	2	24	6	20
Sept. ,,	,,	3	37	21	36
	Total ..	.. ..	147	45	23·4
July 1913	Fallowfield	1	36	6	14
Aug. ,,	,,	2	88	27	23
Sept. ,,	,,	3	41	32	43
	Total ..	.. ..	165	65	28·2

12. *Relation of* Pegomyia hyoscyami *to its Host Plants.*

Random statements are often made by entomologists of the migration of herbivorous insects from one host plant to another, and, although there are well-authenticated cases of certain species becoming serious pests by deserting common weeds to infest cultivated crops which are closely related, I am not at all convinced that this transition always takes place with that abrupt suddenness which many authors assume.

To determine whether adults of *P. hyoscyami*, reared from larvae which had fed on belladonna leaves, would oviposit on the leaves of mangold wurzel, a large number of fertilised females were confined in breeding cages along with fresh mangold plants, but the results were purely negative. In no single instance were eggs deposited. These experiments were repeated with fertilised females reared from mangold

feeding maggots and liberated in cages containing potted plants of belladonna. Again the results were quite negative. From the slight evidence thus obtained one would not be prepared to jump at a general conclusion, but it may just be possible that within the limits of a single polyphagous species, certain well-defined "biologic" species may be established, each of which shows a marked tendency towards one of their food plants. Consequent on this preferential adoption of a host, slight variations may arise such as in the colour, a fact which at one time led to the establishment of the variety *betae* as a species distinct from *hyoscyami*. As has been already noticed the imagos of *hyoscyami*, the larvae of which have had henbane and belladonna for food plants, are distinctly lighter in colour when compared with those the larvae of which have fed on the leaves of beet and mangold.

At Dartford in Kent, where henbane and belladonna are grown on a large scale for the sake of their alkaloid bases, it has been found that, whereas in some years as much as 80 per cent. of damage is done to the former crop by the maggot, the latter remains unaffected, although in close proximity. It would appear that the fly has become thoroughly established on the henbane to the exclusion of the allied belladonna. Of course, it may be that some definite organic substance specific to henbane and not present in belladonna is chemotropic to the fly, which would account for its ovipositing on the one host rather than on the other. When henbane is absent belladonna proves quite attractive.

Much interest, again, is derived from the question why *P. hyoscyami* should select members of the widely different families of Chenopodiaceae (beet, mangold) and Solanaceae (henbane, belladonna) as its host plants. Is it possible that they all exert the same sort of chemical stimulus inducing the one species to oviposit on any of them? Dr Trägårdh (p. 116) says: "If the food of the larva consists of several species of one and the same genus, or of different genera within one or several families, then it is an organic union, or group of such, common to all these, to which the species reacts positively." Again he says (*ibid.*): "The odour of organic matters [*to which the flies orient themselves and are attracted*[1]] is due to the occurrence of certain specific chemical combinations, *e.g.* organic acids, amines, terebines, phenols, glycosides, etc. which are characterised by a certain structure and stratification of the atoms." One can easily perceive the validity of the argument where one is confined to a consideration of a single vegetable

[1] The italics are mine (A. E. C.).

family, but in the present case of the two families Chenopodiaceae and Solanaceae, it lays itself rather open to attack, unless one extends the content of "specific chemical stimulus" to mean not merely that exerted by any one organic substance, but rather by certain of them which have similar groupings of their component atoms (*i.e.* specific *kind* of chemical stimulus). Such for instance are the nitrogen bases of which betaine, guanine, hyoxanthine in the beet, atropine in the belladonna, and hyoscine and hyoscyamine in henbane, all possessing marked physiological or toxic properties, are well-known examples. But it must not be inferred that these substances are attractive to *P. hyoscyami*, for there is no direct proof on this point, but, hypothetically, their presence in these different plant species would satisfactorily explain the varied food habits of the larva.

Since completing this paper, Dr Imms suggests to me the possibility of *betae* being one species confined to the Chenopodiaceae and *hyoscyami* a second species confined to the Solanaceae. The possibility of their being physiological species, which have undergone more or less morphological separation, appears to him as well as to myself, on the sum total of evidence, to be quite a feasible and justifiable proposition.

SUMMARY.

The species *P. hyoscyami* has been recorded at various times by various authors, and it has often been described under different names, partly because of its having been reared from a fairly wide range of food plants. The belladonna leaf-miner is the larva of this species, found during the summer throughout Europe, United States of America and Canada.

The injury to the plant consists in the destruction of the parenchyma which the maggot greedily devours, the leaves assuming a blistered appearance in consequence. The leaves thus attacked quickly flag and wither during dry weather. In this way excessive damage to the various food plants often results in their total loss, heavily affecting the agriculturist pecuniarily where they are grown as cultivated crops.

Other food plants besides belladonna are mangolds, beet and henbane.

The number of the larvae in one leaf varies with the size of the latter and, roughly speaking, directly as the size.

The ravages are periodic and often quite localised, resulting in diminished yields of the products of the different crops attacked. The

top shoots are most heavily infested early in the season, but later the radical leaves are most attacked.

Hibernation occurs in the pupal condition about two inches below the surface of the soil near the food plants.

The number of broods vary. There are at least three in latitude. The broods are not separated sharply off from each other. There is a good deal of overlapping so that all stages occur in the field during the greater part of the season.

The eggs are deposited superficially on the back of the leaf in groups consisting of parallel series varying in number. The incubation period is about 5 days.

The larvae feed uninterruptedly and complete their metamorphosis in 10 days under the most favourable circumstances. The larvae of the first two broods sometimes pupate in the leaf, generally making their way to the margin to do so. The pupal period of the first two broods is about 17 days.

The average period for one complete life-cycle is about 36 days.

Two closely related species, *P. bicolor* and *P. nigritarsis*, attack common weeds such as dock. Their life-histories are, in all details, almost similar to that of *P. hyoscyami*. Structurally, there are some interesting differences, especially in the larval stages.

According to the different food plants which it affects, *hyoscyami* may be divided up into at least two " biologic " species, one of which would seem to confine its energies to a few members of the Chenopodiaceae, the other to Solanaceae, and within these two families preferences to different species are shown. But in the absence of the one favoured food plant, another, not ordinarily so attractive, may be selected.

Species of the Chenopodiaceae and Solanaceae have in common certain specific organic substances belonging to the group known as the alkaloid bases. They probably serve as an attraction to the fertilised females to oviposit on the leaves of the plants which contain the active principles concerned.

Experiments showed that mangold-reared adults would not oviposit on belladonna and *vice versa*. This restriction to one kind of plant is indirectly advantageous to the agriculturist in that strains of flies reared on belladonna confine themselves probably to this species or one closely related, such as henbane, and do not attack mangolds.

The young plants are more easily killed than the more advanced ones.

Natural control of the pest is secured by the parasitism of two species of Braconids on one or both of which a Proctotrypid is probably hyperparasitic.

The degree of parasitism ascends to a climax at the end of August and beginning of September, and then suddenly diminishes.

Frequent hand-picking of attacked leaves and their destruction provides a ready and effective means of killing the maggot and unhatched eggs. This method is only practicable where the crop is a small one.

Dressings of stimulating, chemical manures in the early stages, strengthens the plants so that they maintain themselves the better against the injurious effects of infestation.

Farmyard manure which attracts the flies should where used be applied in the autumn to give it the chance of decaying before the adults appear in the spring.

Deep-ploughing in the autumn serves to bury the hibernating puparia which lie near the surface, thus rendering the emergence of the adults in the spring a matter of comparative difficulty.

Paraffin emulsion is not so effective in killing the maggot as this same emulsion with nicotine added.

BIBLIOGRAPHY.

Banks, N. (1912). The Structure of Certain Dipterous Larvae with Particular Reference to those in Human Foods. *U.S. Department of Agriculture, Bureau of Entomology, Washington, Technical Series*, No. 22, p. 30, Pl. VI, figs. 110, 112.

Bouché, P. Fr. (1834). Naturgeschichte der Insekten besonders in Hinsicht ihrer ersten Zustände als Larven und Puppen. Berlin, 216 pp., 10 pls (*A. mitis* Mg., p. 66, *A. rumicis* Bché, pp. 209–210).

Brauer, F. (1883). Die Zweiflügler des Kaiserlichen Museums zu Wien. III. Systematische Studien auf Grundlage der Dipteren-Larven nebst einer Zusammenstellung von Beispielen aus der Literatur über dieselben und Beschreibung neuer Formen. *Denkschr. der Kais. Akad. der Wiss. math.-naturwiss. Classe*, Wien, vol. XLVII, p. 71.

Brischke, C. G. A. (1881). Die Blattminirer in Danzig's Umgebung. *Schrift. der naturfors. Ges. Danzig*, vol. V, pp. 233–290, figs. 1–5 (*A. femoralis* Brke, p. 275).

Cameron, E. A. (1913). General Survey of the Insect Fauna of the Soil, etc. *Journ. Econ. Biol.*, vol. III, pt. 3, p. 186.

Carpenter, G. H. (1905). Injurious Insects and other Animals observed in Ireland during the year 1904, XIV. *Econ. Proc. Roy. Dub. Soc.* vol. I, pt. 6, pp. 289–291, 2 pls (XXIII, XXIV).

CHITTENDEN, F. H. (1903). A brief Account of the Principal Insect Enemies of the Sugar Beet. *U.S. Dept. of Agriculture, Division of Entomology*, Bull. No. 43, pp. 50–52, 1 fig. (The Beet or Spinach Leaf-Miner, *P. vicina* Lintn.).

CURTIS, J. (1874). Observations on the Natural History and Economy of a Weevil affecting the Pea-crops, and various Insects which injure or destroy the Mangold-wurzel and Beet. *Jour. Roy. Agric. Soc. Eng.*, vol. VIII, pp. 399–416, 1 pl. (*Anthomyia betae.* The Mangold-wurzel Fly, pp. 411–413).

FARSKY, F. (1879). Die ersten Stände zweier Runkelrüben-Fliegen, II. Die Runkelfliege *Anthomyia conformis* Nördlinger (Fall.). *Verh. d. k.-k. zool.-bot. Ges. in Wien*, vol. XXIX, pp. 107–114, 1 pl.

GOUREAU, M. Le Col. (1851). Mémoire pour servir à l'histoire des Diptères dont les larves minent les feuilles des plantes et à celle de leurs parasites. *Ann. d. l. Soc. Ent. de France*, vol. II, pp. 131–176 (*Pegomyia atriplicis* G., pp. 163–166, pl. 7, No. XVI, *Pegomyia mitis* Macq., *Pegomyia rumicis* R.-D., pl. 7, No. XVII).

GUÉRIN-MÉNEVILLE, M. F. G. (1851). Descriptions de plusieurs espèces de Myodaires dont les larves sont mineuses des feuilles de végétaux ; par M. J.-B. Desvoidy, D.M. *Revue et Magasin de Zoologie*, 2nd Ser., T. III (*P. atriplicis* Rob.-Desv., *P. Gouraldi* Rob.-Desv.).

HEWITT, C. G. (1907). On the Life-History of the Root Maggot, *Anthomyia Radicum* Meigen. *Jour. Econ. Biol.*, vol. II, pt. 2, pp. 56–63, 1 pl.

HOLMGREN, A. E. (1880). Bladminerande Fluglarver pa våra Kulturväxter. *Entom. Tidskr. på föranstalt. af Entom. Fören. i Stockholm*, vol. I, pt. 2, pp. 88–90. (Spenatflugan, *Anthomyza spinaciae* Holmgr., Rödbetsflugan, *Aricia betae* Holmgr.)

JABLONOWSKI, J. (1905). Die tierischen Feinde der Zuckerrübe, 399 pp., 75 figs., Budapest. Die Runkelfliege, chap. XI, pp. 303–315, figs. 61–63.

KALTENBACH, J. H. (1874). Die Pflanzenfeinde aus der Klasse der Insekten. Stuttgart (*A. conformis* Mg., pp. 504–505, *A. betae* Scholtz, p. 510 *ibid.*, *A. hyoscyami* Mg., p. 456 *ibid.*, *A. nigritarsis* Ztt., p. 456 *ibid.*, *A. bicolor* Wied. p. 519).

LOCHHEAD, W. (1903). Insects of the Season. *Ann. Rep. Ent. Soc. Ont.*, No. 34, pp. 31–36 (*P. vicina*).

LUNDBECK, W. (1900). Diptera groenlandica. *Vid. Medd. f. d. naturhist. For. i Kjøbenhavn*, Sjette Aartis, p. 287.

MARTELLI, G. (1909). Altre Notizie Dietologiche della Mosca delle Olive. *Boll. d. Lab. d. Zool. Gen. e Agr. d. R. Scuola Superiore d'Agricoltura in Portici*, vol. IV, p. 93 (Accopiamento).

MEADE, R. H. (1883). Annotated List of British Anthomyiidae. *Ent. Monthly Magazine*, vol. XX, pp. 9–14 ; *ibid.* vol. XXIV, p. 58.

MEIGEN, J. W. (1826). Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten, vol. V, p. 182 (*Anth. hyoscyami* Mg.), p. 180 (*A. conformis* Fall.), p. 181 (*A. egens*), p. 184 (*A. exilis*).

NÖRDLINGER, H. (1855). Die kleinen Feinde der Landwirthschaft oder Abhandlung der in Feld und Haus schädlichen oder lästigen Kerfe, sonstigen Gliederthierchen, Würmer und Schnecken, mit besonderer Berücksichtigung ihrer natürlichen Feinde und der gegen sie anwendbaren Schutzmittel. pp. 556–560 (Die Runkelfliege, *Musca* (*Anth.*) *conformis* Fall.).

Ormerod, E. A. (1880–95). Report of Observations of Injurious Insects and Common Crop Pests with Methods of Prevention and Remedy. London.

Réaumur, R. A. F. (1737). Mémoires pour servir à l'histoire des Insectes. Paris, Imprim. Royale, vol. III, pp. 42 et 532, tab. 47 (Pégomyie de la jusquiame).

Robineau-Desvoidy, A. J. B. (1830). Essai sur les Myodaires, p. 598.

Rondani, C. (1866). Anthomyinae Italicae Collectae Distinctae et in Ordinem Dispositae. *Atti della Societa Italiana di Scienze Naturali*, pp. 68–217. (*Chortophila chenopodii* Rond., *C. cunicularia* Rond., *C. perforans* Rond., *C. hyoscyami* Mgn., *C. effodiens* Rond.)

Schiner, J. R. (1862). Fauna Austriaca: Die Fliegen. Wien, vol. I, 674 pp.

Scholtz, H. (1848). Zwischen der Ober- und Unterhaut des Blattes Minirlarven. *Ent. Zeit. Breslau*, vol. II, pp. 10–11.

Stein, P. (1906). Die mir bekannten europäischen Pegomyia-Arten. *Wiener Entom. Zeitung*, vol. XXV, pp. 47–107. Wien.

Stift, A. (1903). Die Runkelfliege (*Anthomyia conformis* Fall.). *Wiener landwirtsch. Zeit.* Wien, vol. LIII, p. 423.

Taschenberg, E. L. (1880). Praktische Insekten-Kunde, IV. Die Zweiflügler, Netzflügler und Kaukerfe. Bremen, pp. 123–125.

Theobald, F. V. (1909–11). Report on Economic Zoology. London (Annual Reports).

Trägårdh, I. (1913). On the Chemotropism of Insects and its Significance for Economic Entomology. *Bull. Ent. Research*, vol. IV, pt. 2, pp. 113–117.

Tullgren, A. (1905). Om Fluglarver på Spenat. *Upp. i Prakt. Entom. med Statsbid. Utgif. af Entom. Fören. i Stockholm*, pp. 76–80 (*Anthomyia* (*Pegomyia*) *dissimilipes* Zett.).

Vallot, J. N. (1849). Eclaircissements relatifs à plusieurs passages des Mémoires de Réaumur. *Mém. Acad. sc. Dijon*, pp. 81–111.

Vassiliev, E. (1913). The Entomological Section of the Report of the Experimental Entomological Station of the All Russian Society of Sugar-Refiners for 1912. Kiev. pp. 12–13 (*Résumé* in *Rev. App. Ent.*, vol. I, Ser. A. pt. 12, 1913, p. 487).

Westwood, J. O. (1840). An Introduction to the Modern Classification of Insects. London, vol. II, p. 571.

Zetterstedt, J. W. (1846). Diptera Scandinaviae disposita et descripta, Lund, vol. V, pp. 1791–2.

EXPLANATION OF PLATES I AND II.

[For purposes of reproduction it has been necessary to reduce the size of the figures by $\frac{1}{5}$th. The magnifications given refer to the author's original drawings. *Eds.*]

Fig. 1. Dorsal aspect of the egg of *Pegomyia hyoscyami*. ×80.

Fig. 2. Mature larva of *P. hyoscyami*. ×10·5. *pt.sp.* prothoracic spiracle.

Fig. 3. Posterior aspect of ultimate segment of same to show the position of the tubercles and the posterior stigmata (*p.sp.*). *an.* anus (highly magnified).

Fig 4. The three first segments of same, ventral aspect. ×15. *s.p.* sensory papilla; *a.* antenna; *md.s.* mandibular sclerite; *pt.sp.* prothoracic spiracle.

Fig. 5. Prothoracic spiracle of mature larva (very highly magnified).

Fig. 6. Larva of second stadium. ×23.

Fig. 7. Posterior aspect of ultimate segment of same to show the tubercles and posterior stigmata (*p.sp.*). ×34. *an.* anus; *a.l.* adanal lobes.

Fig. 8. Mature larva of *Pegomyia bicolor.* ×10·5. *pt.sp.* prothoracic spiracle; *p.sp.* posterior spiracle; *a.p.* anterior ventral protuberance ("foot").

Fig. 9. Posterior aspect of ultimate segment of same, showing arrangement of tubercles and posterior spiracles (*p.sp.*). ×11. *a.l.* adanal lobes; *an.* anus.

Fig. 10. Larva of second stadium of same. ×27. *p.sp.* posterior spiracles.

Fig. 11. Prothoracic spiracle of mature larva of *Pegomyia bicolor* (highly magnified).

Fig. 12. Posterior aspect of ultimate segment of mature larva of *Pegomyia nigritarsis.* Tubercles are numbered; *2a*, *3a* placed more postero-laterally than the others. *p.sp.* posterior spiracle; *an.* anus.

Fig. 13. Puparium of *P. hyoscyami*—ventral view. ×7.

Fig. 14. Puparium of *P. bicolor*—ventral view. ×8.

Fig. 15. Buccal-pharyngeal apparatus of mature larva of *P. hyoscyami*—right lateral aspect, drawn from preparation previously treated with potash and mounted in canada balsam (camera lucida). ×40. *md.s.* mandibular sclerite; *i.s.* interstitial sclerite; *h.s* hypostomal sclerite; *c.p.s.* cephalo-pharyngeal sclerite; *pf.s.* perforate sclerite; *d.p.* dorsal arm of cephalo-pharyngeal sclerite; *v.p.* ventral process of cephalo-pharyngeal sclerite; *a.* antenna.

Fig. 16. Buccal-pharyngeal apparatus of *P. bicolor* (the preparation similarly treated to the previous). ×18. Lettering as in Fig. 15. *pt sp.* right prothoracic spiracle. The two subtended arms of the dorsal processes shown, one of which belongs to the left cephalo-pharyngeal sclerite.

Fig. 17. The same dissected out and more highly magnified. For significance of lettering refer to Fig. 15 (camera lucida). *d.p.* denticular process.

Fig. 18. Left wing of adult female of *P. hyoscyami.* ×26. *an.* anal lobe; *al.* alula; *as.* antisquama; *aux.* auxiliary vein; 1–6 first to sixth longitudinal veins; *c.v.* costal vein; *h.v.* humeral vein; *cr.v.* anterior cross-vein; *a.cr.v.* anterior basal cross vein; *p.cr.v.* posterior basal cross vein; *c.c.* costal cell; *s.c.* subcostal cell. *m.c.* marginal cell; *sm.c.* submarginal cell; $p.c.^1$, $p.c.^2$, $p.c.^3$, first, second, and third posterior cells; *d.c.* discal cell; $b.c.^1$, $b.c.^2$, first and second basal cells; *a.c.* anal cell.

Fig. 19. Left anterior leg of adult female of same, to show arrangement of the bristles. ×19. *tr.* trochanter; *f.* femur; *t.* tibia; *ta.* tarsus.

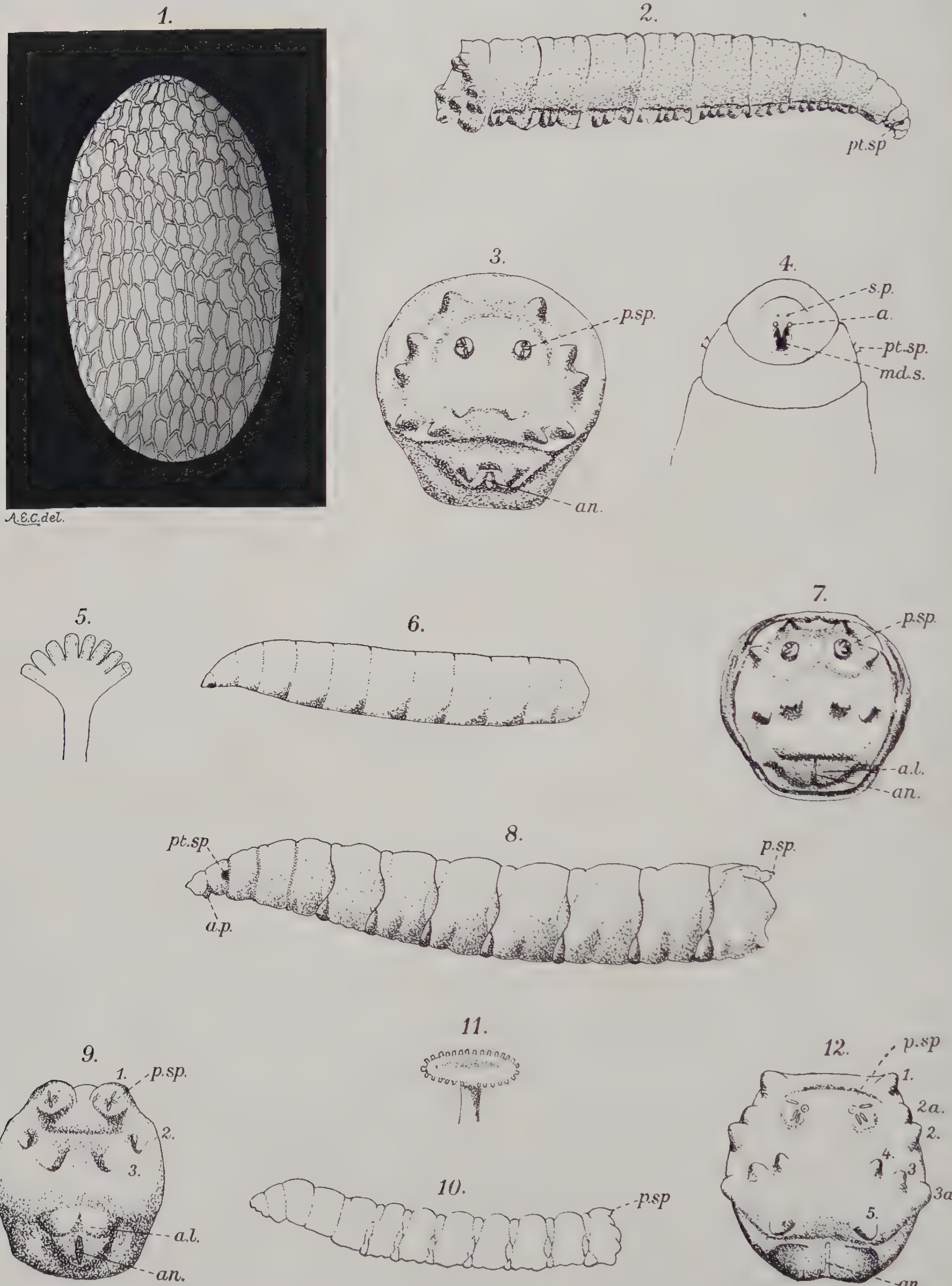
Fig. 20. Middle left leg of same. ×29·5. Lettering as in Fig. 19.

Fig. 21. Posterior left leg of same. ×26·5. Lettering as in Fig. 19.

Fig. 22. Adult female of *P. hyoscyami.* ×15.

Fig. 23. Mature larva of *Opius nitidulator.* ×16. Drawing made from specimen dissected out from a puparium of *P. hyoscyami.*

Figures 16, 18, 19, 20, 21 were drawn with the aid of the Zeiss-Greil drawing apparatus by means of which most exact reproductions are obtained.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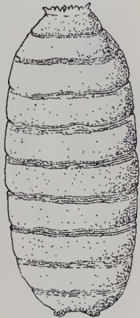

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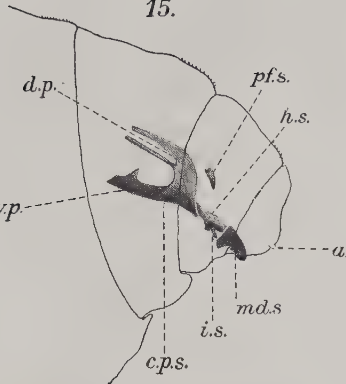

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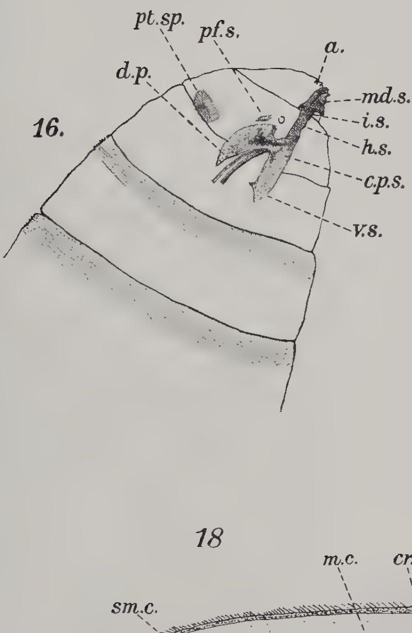

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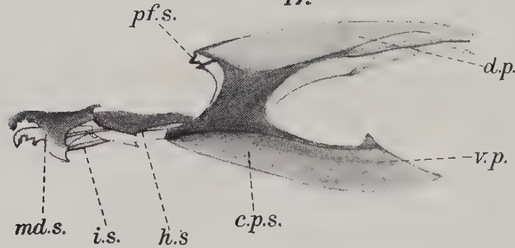

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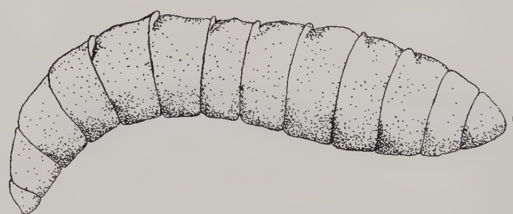

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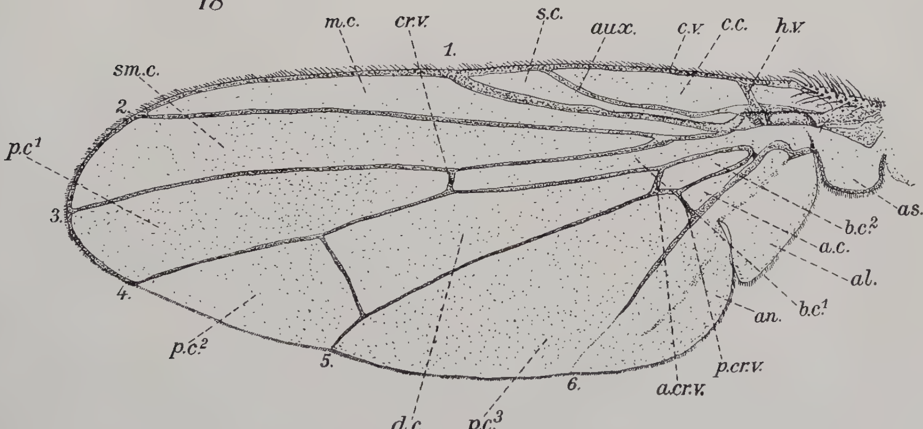

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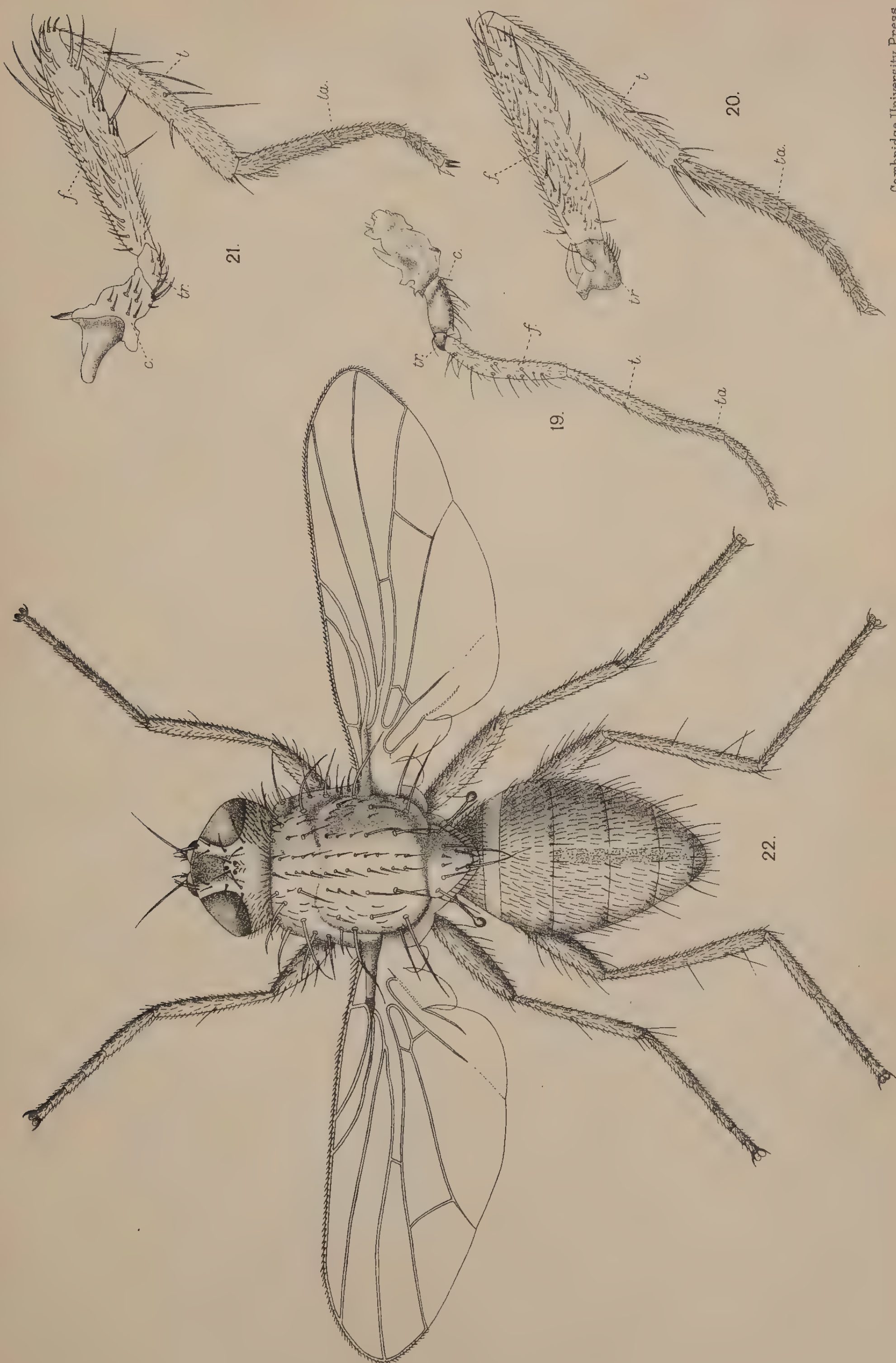

Pegomyia hyoscyami.

THE CATERPILLARS ATTACKING THE OAKS OF RICHMOND PARK, WITH AN ACCOUNT OF AN EXPERIMENTAL SPRAYING WITH LEAD CHROMATE.

By R. H. DEAKIN.

The oak trees of Richmond Park have suffered very extensively of late years from the attacks of caterpillars.

I have not personally seen the damage done in previous years, but from all accounts the trees last year (1912), as also the year before, were almost stripped of foliage, presenting as a result the appearance of dead trees. A secondary growth of foliage then occurs. The period of maximum damage is said to have occurred in June, the time doubtless varying with the weather conditions in the spring. Impressed by the serious nature of the damage, the authorities at Kew Gardens communicated with the entomological department of the Royal College of Science, and Professor Lefroy, under whose guidance I have been working, took the matter up.

It was decided that one section of the oaks in the park should be kept under observation and sprayed and for this purpose Ham Cross Plantation, consisting of some 400 large oak trees planted in 1825, was chosen.

This plantation, presenting a very compact area of trees, has been very severely attacked in previous years.

I first visited the plantation in the third week of April. Some half dozen trees were already breaking into leaf and on these minute caterpillars were observable.

From this time onwards the number of caterpillars and the accompanying damage to the leaves increased rapidly, and it became possible to collect the different forms for the purpose of breeding out the moths.

The two commonest caterpillars were soon seen to be those of *Tortrix viridana*, the leaf-roller moth, and *Cheimatobia brumata*, the winter

moth. The caterpillars of these two forms of moth far outnumbered the rest of the species present. The leaf-roller was likewise somewhat more numerous than the winter moth.

The moths bred out were identified in the British Museum.

The following is a list of the species identified, the geometers being identified from their caterpillars.

Noctuidae.	*Calymnia trapezina* L.
Geometridae.	*Oparabia dilutata* Bkh.
	Hybernia defoliaria Cl.
	Cheimatobia brumata L.
Tineina.	
Sparganothidae.	*Batodes* (Capua) *angustiorana* Hw.
Olethreutidae.	*Spilonota ocellana* Schiff.
	Gypnosoma dealbana Fröl. (*incarnana* Hw. nec Hb.)
Tortricidae.	*Tortrix viridana* L.
	Tortrix (Pandemis) *ribeana* Hb.
	Archips (Cacoecia) *podana* Sc.
	Archips (Cacoecia) *xylosteana* L.
	Archips (Cacoecia) *lecheana* L.
Coleophoridae.	*Coleophora lutipennella* Z.

C. trapezina was not very numerous, only a few caterpillars being found. The moths hatched out at the beginning of June. These were the largest caterpillars found on the oak, but owing to their small numbers can hardly be classed as pests.

O. dilutata was also scarce. One caterpillar of this species was found parasitised, presumably by a Tachinid, the egg of the fly adhering to the dorsal surface of the caterpillar. Unfortunately the adult was not bred out.

Although nothing like so numerous as either, *Hybernia defoliaria* ranks next in importance after *C. brumata* and *T. viridana*. Being of a fair size and of an active disposition it causes considerable damage to the leaves. *C. brumata* was very numerous and a large proportion of the damage must be attributed to this caterpillar. The caterpillars of this species disappeared about the beginning of June, pupating in the ground below the trees. The use of grease bands to catch the fertilised female as she climbs the tree to lay her eggs should help to keep this pest in check.

Of the Microlepidoptera, none of the species identified are sufficiently numerous to be considered as pests with the exception of *Tortrix viridana*. *Archips lecheana* L. occurred pretty frequently and was successfully

bred out from a dark greenish-black caterpillar, yellowish-green ventrally and laterally and on the dorsal surface of the last two or three abdominal segments. Head dark brown with two black bands. Prothorax deep black. The caterpillar of *Archips podana* Sc. is almost an inch long when fully grown. The colour before the last moult is greenish-blue, with four spots of lighter colour on the tergum of each segment. Head reddish-brown.

Tortrix ribeana was bred from a caterpillar characterised by the size and prominence of the dorsal spots, these being white and the rest of the body pale green. Head with three or four longitudinal brown stripes. This moth was first hatched out on June 3rd.

Coleophora lutipennella Z., is quite common on the oak, the caterpillar living in a tube and boring under the epidermis of the leaf—this resulting in a dead brown patch on the surface. The caterpillar of another Tineid moth, *Lithocolletis* sp., was found to be very common during June, many leaves being covered with areas of dead epidermis due to the mining of the caterpillar.

Gypnosoma dealbana Fröl., I am told, has not previously been recorded from the oak.

By rolling up the leaves and eating the area so enclosed, *T. viridana* causes considerable damage. I was never successful in finding the eggs in the spring, but judging from the position of the young caterpillars on the early buds of the oak, the eggs themselves cannot be very far from these buds, if not actually on them. I believe the eggs of *T. viridana* have never been observed and described. The larvae are full grown in three to four weeks and pupate under the rolled up leaves. By the 4th of June almost all the caterpillars of *T. viridana* on isolated oaks in the park had pupated, those on the Ham Cross Plantation being slightly later. The period of pupation lasts roughly a fortnight and by the 15th of June many moths were found hidden in the lower branches of the oaks.

About this time I observed on the trees a considerable number of minute pale coloured caterpillars of the leaf-rolling type. The original brood of *T. viridana* had so far as is known all by now pupated, and the question arose, Is this a second brood of *T. viridana.* The caterpillars had the characteristic appearance of those of *T. viridana* and their occurrence when the original brood had apparently all pupated seems to support the idea of a second brood.

Moths kept in captivity were found in copulation and one female later laid eggs on the back of an oak leaf, about June 12th. The eggs

were rounded, slightly flattened and of a yellowish-brown colour. They were about ·75 mm. across and occurred singly or in twos or threes buried in scales from the abdomen of the moth and in some cases with bunches of scales sticking out like bristles.

Although unfortunately not absolutely established I think there is little doubt that a small caterpillar found eating the epidermis of the leaf some days after the eggs were laid had hatched out from one of these same eggs.

Other eggs however failed to develop, so that this question of a second brood remains somewhat doubtful as I was unfortunately obliged to give up the investigation at this critical period. Most writers say nothing of the existence of a second brood. Judeich and Nitsche in their *Lehrbuch Forstinsektenkunde* (1895) believe there is but one generation, but mention other German investigators who believe that two exist, and that the second hibernates as a pupa from which the moths appear in April, the second brood of moths in the year appearing in June and July. One of these investigators (Feussner on *T. viridana*, *Zeitschrift für Forst u. Jagdwesen*, VI, 1874), found larvae and pupae, which he believed to be *T. viridana*, in leaves spun together, the time being the end of September. He was unsuccessful however in rearing the moth from them.

The importance of this question is obvious as it concerns not only the second brood and hence the liability of the oaks to a second attack but also the way in which the first brood makes its appearance in the spring.

Should it be found that the foliage undergoes a second attack, by leaf-rolling caterpillars, and I believe it has been observed that the attack does occur in two stages, then the problem of this second brood should be easy of solution. A large sawfly larva was found to be fairly common on the oak and under conditions favourable to its increase might develop into a pest.

Natural Checks.

Large numbers of rooks and starlings were noticed in the tops of the oaks of the plantation, doubtless feeding on the caterpillars.

The wild birds in the park have been artificially fed during the winters of 1910–11 and 1911–12. Last winter being an open one, much less feeding was done and Mr Pullman, the park superintendent, suggests that the tits and other small birds, being dependent on the natural supply

of food, may have done something to account for the comparatively small amount of damage, which this year has been done to the oaks by the caterpillars. Unless however *T. viridana* hibernates as a pupa, which might serve as food for the birds, these could do little good in the winter unless indeed they eat the eggs of *T. viridana* and *C. brumata*.

Parasites. *Oparabia* has been mentioned as being parasitised by a Tachinid fly.

No case of parasitism on the winter moth larva was observed.

Only a small percentage of leaf-roller caterpillars were parasitised.

At the beginning of June 60 pupae were collected from the trees and from these 43 moths hatched out. Twelve pupae died but were not parasitised. The remaining five were parasitised, two by an Ichneumon (*Pimpla arctica*), one by a Braconid (*Meteorus laeviventris* (Wesm.) and two by Tachinid flies one of which was hatched out and identified as *Thrytocera* (*pilipennis* Fln. ?).

This gives a percentage of about eight parasitised caterpillars. The 60 pupae were not actually identified as *T. viridana*, but since all the moths which appeared were of this species there is little doubt that the parasites appeared from this species also, but this requires confirmation. A caterpillar of *T. viridana* was also found with four bright green hymenopterous larvae attached to the hinder part of the thorax.

The caterpillar's condition was quite normal, it was apparently about to pupate.

The larvae which were about one-eighth of an inch long when full grown, existed on the still living caterpillar for three days and then left it and spun rough webs on the sides of the vessel in which they were kept. They failed however to continue their development.

Artificial Methods of Control.

Two days, May 6th and 7th were spent spraying the trees of the Ham Cross Plantation, it being hoped to cover the leaves with a stomach poison whilst the caterpillars were still young. The spray used was made from a paste of the following composition:

Lead chromate	20 or 50 %
Soft soap	10–25 %
Gelatine	·6–1·5 %
Water	9·4–23·5 %

I believe this is almost the first time lead chromate has been used in this country as a stomach poison for insect pests. The supply used

was an experimental lot, and cost £5 per cwt. One pound of the paste was used to about 30 gallons of water, this giving 1 lb. of lead chromate to every 60 gallons of spray.

Messrs Merryweather of London supplied us with a 3 h.p. petrol driven pump with sufficient metal piping and flexible tubing to reach right across the plantation. Six jets were available and with the pump working at full pressure each jet was spraying about one gallon per minute. (See Plates III, IV, V.)

About twenty students and others from the college were present to do the spraying, and mix the material.

Considerable time was spent in moving the engine and laying out the mains; rain delayed matters, and only about eight hours during the two days were actually spent in spraying.

The water was supplied in water carts by the park authorities, and a second petrol pump was used to pump it into the galvanised iron tanks in which the spray was mixed. Two of these tanks were used, each holding about 30 gallons of water, and as one was being emptied the spray was made up in the second. One pound of paste was softened in a bucket with warm water from the engine and diluted down to 30 gallons. In this way the solid matter was obtained in a very fine state of suspension, forming an admirable spray to work with. No trouble was experienced due to the paste settling to the bottom of the tanks.

During the two days some 1700 gallons of spray were used, practically every tree being reached. The pressure however was quite insufficient to drive the spray to the tops of the oaks. On the second day a fire escape was provided and with its help many of the tallest trees were thoroughly sprayed all over (Plates VI, VII). The days chosen for the spraying were the only ones available, and there is little doubt that at least a week later would have been better as then the trees would have presented a much larger area of foliage. Moreover the leaves being more fully grown would not so readily have caused the breaking of the film of spray (viz. solid matter from the spray) by their expansion, as actually was the case. On the other hand the caterpillars would have been older and hardier at this later date.

The attack of caterpillar has, throughout the park generally, been very slight this year and the damage up to the end of June inconsiderable, though one or two trees were noticed which either on account of caterpillars or for some other reason never from the beginning appeared to have the normal amount of foliage and presented a very bare appearance.

Nor can it be said that the Ham Cross Plantation fared better or

worse than the rest of the oaks in the park. Had the attack been as bad as last year's, doubtless a contrast would have been apparent between those trees which were thoroughly sprayed and trees outside the plantation which were not touched. The growth of the leaves was very rapid during the favourable weather which followed the time of the spraying, and the coating of spray, observable for some days and quite unaffected by exposure and rain, finally disappeared owing to the expansion of the leaf. Rain fell while the trees were being sprayed and to some extent this must have affected the deposition of the spray. Caterpillars fed on sprayed foliage either died at once or became starved and finally perished, so that no doubt remains as to the efficacy of the poison.

The question of the falling off in the severity of the attack this year is an interesting one. The possibility of birds influencing this, has already been touched upon.

It is possible that last season the parasitic enemies of the chief caterpillar pests were very numerous, thus lessening the numbers this year. The caterpillars appeared however to be numerous enough, especially those of *T. viridana.* It may be that the dry sunny weather of May and June this year (1913) so favoured the rapid growth of the oak foliage that this easily kept ahead of the attack of the caterpillars, the growth of foliage being greatest when the caterpillars were most numerous and dangerous.

It can readily be understood that if the growth of the foliage is delayed by unfavourable weather the caterpillars will gain the upper hand and the foliage already present will disappear and the tree will assume the bare appearance typical of years of bad attack. The weather last year (1912) I believe was favourable for the trees till the beginning of June when the weather became colder and damper. If the caterpillars were still active at this time, they may have caused the stripping of the trees, on the cessation of the fine weather.

I should like to take this opportunity of thanking Professor Lefroy for the advice and assistance which he gave me during this investigation, and Mr Pullman, the park superintendent, for his advice about the trees and caterpillars.

[Mr Deakin's observations were put an end to by his appointment as assistant to the Government entomologist, British East Africa. The almost entire absence of any visible effects of caterpillar attack anywhere in Richmond Park in 1913 destroyed the value of our experiment as no plantation in the park was affected. But it showed that

trees could be sprayed in England as elsewhere, and that the cost was not excessive. For approximately 400 trees, 1700 gallons were used or 56 lbs. of lead chromate paste.

Our thanks are due to Messrs Merryweather who provided the machinery and ladders; their apparatus worked admirably, even though we had hundreds of yards of main, branch and rubber pipes out at a time: the whole work was done by students except the actual control of the petrol-driven motor. The illustrations attached speak for themselves.

To the courtesy of the Office of Works, we owe the opportunity to make this experiment; it is unfortunate that no result was obtained. H. M. Lefroy.]

General view of the machine showing main pipe.

[Photo by Clarke & Hyde

The motor pump.

[Photo by Clarke & Hyde

Mixing wash.

Using telescopic ladder.

Spraying the tallest trees.

Lifting the motor.

Coupling main pipes.

A BACTERIAL DISEASE OF FRUIT BLOSSOM.

By B. T. P. BARKER, M.A. and OTTO GROVE.

(*University of Bristol: Agricultural and Horticultural Research Station.*)

In the *Gardeners' Chronicle* of May last year an announcement was made by one of us that several cases of blackening of pear blossoms, commonly supposed to be due to frosts or cold winds, had been traced to the action of a bacterium. For several seasons past the blackening of the blossom followed by the death of the flower has been observed in the plantations of this institution at Long Ashton, the severity of the attack varying from year to year, but on the whole showing a tendency to increase. In the spring of 1913 the disease was much more marked than at any time previously; and although the trees of most of the varieties grown there were heavily laden with blossom, the crop was a failure, certain varieties being especially severely attacked and failing to produce more than half a dozen or so mature fruits per tree on good sized trees ten or twelve years old. Until then no particular attention had been given to the disease, the damage being attributed to the action of frost and cold winds according to the generally accepted view. Mr J. W. Eves, at that time pomologist at this station, observed during the course of pollination work on pears early last April that in many instances the pistils of unopened flowers were already badly discoloured, and was impressed with the general resemblance of the features of the disease to an attack by a parasitic organism rather than to damage caused by unfavourable weather conditions. He accordingly submitted to us typical diseased blossoms for examination, selecting cases where frost could not possibly be held responsible for the damage. In the case of the first flower examined a large semi-transparent gelatinous-looking colony of bacteria was readily seen under the low power of the microscope situated on the surface of the discoloured disc of the flower. From this colony streak and plate cultures on beerwort gelatine were at once made, and in these in the course of two or three days abundant growth was obtained. The cultures in all cases proved to be pure, only

one type of organism, a rod-like bacillus, developing. After the necessary trials to test purity, stock cultures were made, and material from these was taken for use in infection experiments. The latter gave positive results quickly and without any difficulty, the characteristic discolouration of the flowers following a few days after infection.

It was thus soon demonstrated that the disease was bacterial in nature; and a detailed study of it was begun. Our work is still incomplete, the limited duration of the flowering season curtailing infection experiments and other observations on the flowers themselves in a living condition; but it has been thought desirable to publish a preliminary account of the disease rather than to defer it until the results of the current season's work are available. The present paper is concerned primarily with the general characters of this disease, which, so far as we are aware, has not hitherto been recorded, and a description of the causal organism.

The Characters of the Disease.

The nature of attack and the result vary considerably in individual flowers; but the two following forms are perhaps the commonest.

In the one case the sepals are the first parts of the flower to show signs of attack. Their tips turn grey and then begin to blacken. When weather conditions favour the disease this blackening soon spreads to the whole of the calyx and in due course down to and along the flower stalk. The infection of the latter quickly leads to the death of the whole flower bud. This mode of attack is common with young, unopened flower buds. The flower bud blackens and shrivels up. In moist weather it soon falls from the blossom truss; but under drier conditions it withers and dries up, remaining attached to the flowering shoot or spur for weeks or even months. It is not uncommon to find in late summer whole trusses of these blackened mummified blossoms still on the spur. In cases where the whole of the blossoms of a truss are affected, the consequences as regards the future history and fruiting capacity of the spur bearing the truss are serious. The whole truss of blossom eventually dies and falls off, leaving the spur as a bare stump devoid of foliage. This stump may eventually die back entirely to the point of its attachment to the branch carrying it; and in such cases, if numerous, the future fruiting capacity of the tree is seriously restricted for several seasons at least, until new growth and fresh fruit spurs have had time to develop, on account of the large stretches of barren

branches thus created. In less severe cases the apical portion of the spur is alone affected, dormant buds in due course breaking to form fresh growths ; but even in such instances some time must elapse before the spur is once more properly furnished with fruit buds. The variety Catillac seems particularly susceptible to the disease in this form ; and trees of this sort at Long Ashton are laden with spurs showing this type of damage in all degrees.

In the other case the first signs of trouble appear in the receptacle of fully opened flowers as minute greyish-black spots. These rapidly increase in size until they finally coalesce. In a short time the entire receptacle is blackened and the disease spreads to the ovary. As a consequence the fruit fails to set properly and sooner or later drops from the spur as in the type of attack previously described. The main difference between these two forms of attack is that in the case first described the initial points of infection occur in the external whorls of the flower, the disease catching the eye therefore at a very early stage, whereas in the second instance the attack begins on an internal structure of the flower and may escape observation entirely, the failure of the fruit to set properly being attributed wrongly to imperfect fertilisation.

In both cases the description given applies to examples in which the disease spreads comparatively rapidly through the floral structures ; but under some conditions the extension of the disease proceeds more slowly. Before it has made serious headway the fruit may have set and even have swelled to the size of a pea or larger before the injurious effect puts a stop to further development. Sooner or later, however, the death of the young fruit generally results, although in a few cases signs of attack have been noticed on quite large fruits ; and it is possible that at times an affected fruit may actually reach maturity without serious damage. Such cases are probably infrequent if the disease once establishes a footing. The rapidity of the spread of the disease in an infected flower appears to vary considerably, depending largely upon climatic conditions. Cold, wet weather seems to favour its development and, conversely, warm dry weather restricts it. Further reference to the influence of various conditions will be made later.

In addition to these two typical forms of attack a variety of other types has been observed. In some cases the stigma is first affected, becoming unhealthy and discoloured in appearance. The blackening extends thence downwards through the style to the ovary, the whole pistil eventually turning completely black and failing to develop into a fruit. In other cases small blackened areas appear first on one or more

of the petals. The remaining parts of the flower may or may not be attacked in due course. In the latter event the affected petals fall as the flower ages, and the young fruit may then develop normally.

While attacked flowers at times remain attached to the fruit spur for a comparatively long period, even when the disease has obtained a strong hold, it is very common to find flowers which fall at the slightest touch, although the external signs of disease are limited to a few small black spots on the receptacle. A slight shaking of the tree suffices to cause blossoms in all stages of development to fall in showers. Young fruits which appear to have just set are particularly liable to come off in this manner. Examination of the internal parts of the flower in such cases generally shows that the ovary is more or less completely blackened.

The disease spreads very rapidly from flower to flower; and, if it makes its appearance when the tree is just beginning to blossom, it may spread to nearly all the flowers on the tree during the three to four weeks over which the latter is carrying open blossom.

While the disease in its most serious form is concerned mainly with the flowers, other parts of the tree are attacked. The young leaves which appear during the blossoming season frequently show small black spots or areas, very similar in general character to the blackened spots which occur at the points of infection on the petals. Serious damage to the foliage does not generally result, the spots remaining small and eventually drying up and falling out. The leaves developing around the blossom trusses on the fruit spurs are usually most severely attacked. The disease on the foliage generally starts at the tip of the leaf, but occasionally at some point along the margin.

The fruit spurs of the tree are also often attacked; and it is possible that this feature of the disease may prove to be the most serious. Reference has already been made in passing to the fruit spur attacks when describing the course of the disease of the blossom trusses: and it has been shown that after the death and fall of the flowers of the truss the spur is left as a barren stump, which sometimes dies back as far as the point of its attachment to the branch carrying it, but occasionally survives and produces lateral growths which develop in due course into either shoots or branch spurs. In both cases the tissues of the spur are attacked by the bacillus. When death of the spur results, apart from the loss of the spur by the tree no evil effects may follow; but if the spur survives, the infected tissues harbour the organism throughout the summer and winter and may prove to be responsible for an outbreak

of the disease the following spring through the lateral buds which were formed after the original attack. On cutting transverse sections through such a spur just below the point of attachment of the diseased flower truss a number of small brown spots are seen, both inside and outside the cambium. In longitudinal section these appear as brown lines, which at times extend back $\frac{1}{2}$–1 inch or more into the woody portion of the spur. The bacillus is present in these affected portions; and proof is now forthcoming that it remains in a living condition there over the winter. It seems likely, therefore, that new growths from such spurs are also infected. The affected portions of the tissues of the spurs do not increase in size to any considerable extent; and no serious damage to the surrounding tissues results immediately, except in the severe cases where the whole body of the spur dies back. Possibly in the latter event the death of the spur may be due not so much to the organism in question as to fungi, such as *Nectria ditissima* or *Sclerotinia fructigena* which have the opportunity of infecting the spur at the point of severance of the blossom truss. At present no decisive evidence either way has been obtained; but, as will be seen later, infection experiments with the bacillus on woody branches have shown little serious damage, and the balance of probability therefore points to the action of other organisms in cases where the spur dies back.

In the foregoing description of the disease reference has been confined to its characters on the pear as host. There is reason to believe, however, that a number of other plants are also susceptible to attack. A bacteriological examination of discoloured parts of flowers of apples, cherries, gooseberries, and plums has been made, and in many cases there has been found in the diseased areas a bacillus in practically a pure state, which on isolation has proved to be the same organism as that occurring on the diseased pear flowers. It has also been found on the tissues of the flowers and leaves of various other plants in parts showing discolouration. Since at present, owing to our attention having been given mainly to the disease on the pear, very few infection experiments have yet been made on the other plants mentioned, the evidence connecting the bacillus with the disease in the latter cases is not absolutely conclusive; and pending further investigation it is not proposed here to do more than call attention to the fact of the occurrence of the organism in association with affected parts on other kinds of plants.

There appears to be a marked difference in the susceptibility of different varieties of pears to attack. The organism has been isolated from diseased flowers of practically all the varieties grown in the plantations

at this institution, including the following kinds: Beurré d'Amanlis, Catillac, Vicar of Winkfield, Louise Bonne de Jersey, Conference, Bellissime d'Hiver, Dr Jules Guyot, Williams' Bon Chrétien, and Pitmaston Duchess. Of these sorts the two first named are much more badly attacked than the remainder; and most of the trees of those kinds, although covered with blossom, produced very few fruits in 1913, some indeed failing to yield a single pear. After examination of the older fruit spurs of the trees of all of the varieties named, it is evident that also in years prior to 1913 the two varieties in question have suffered more severely than the other kinds.

In the case of apples discoloured flowers of Beauty of Bath, Bramley's Seedling, Allington Pippin, Devonshire Quarrenden, and Duchess of Oldenburgh have been examined, and from each sort the bacillus has been isolated. There is not sufficient information available yet to show if some varieties are more susceptible than others. Few kinds of plums have yet been examined; but cultures of the bacillus have been obtained from the Victoria variety and the Myrobella plum. Only two cases of cherry blossom have been examined, viz. the Norwegian cherry and a kind sent through the Board of Agriculture without name. In both instances the organism was isolated.

There is little doubt from the specimens of fruit blossoms examined last year that the disease is very widely spread. Not only was it repeatedly found in the immediate neighbourhood of Bristol, but also in many other parts of the country. The bacillus has already been isolated from affected pear flowers sent to us from Devon, Teddington, Wolverhampton, Stroud, Ross, and Offenham; and from apple blossom sent from Berkeley, Ledbury, Elsenham, Essex, and Hailsham. The occurrence of the organism over so wide an area suggests the probability of a general distribution throughout the midland and southern counties at least; and the fact that it has been isolated from a number of plants other than pears and apples, in which blossom or foliage damage was slight, raises the question of its pathogenic character in all cases.

It undoubtedly is responsible for the disease of pear blossom in the forms already described, since branches of pear trees carrying unopened and undamaged blossom have been brought on under greenhouse conditions and have in due course borne flowers which have developed the disease both after artificial inoculation with the bacillus and in many cases without deliberate infection. Also abnormally late blossoms produced in the open in June have been found to be affected. In such instances the possibility of frost damage has been excluded, care having

been taken to ascertain that the flowers showed no sign of such damage before being selected for the experiments under cover. On the other hand many cases occur under outdoor conditions in which it is difficult to decide whether the damaged blossom has been affected by the organism or by frost, the type of damage appearing to the naked eye very similar in either case. Again in other instances there is no question of the damage being due to frost. In this connection it may be noted that the blackening or browning of the pistils in unopened or partially opened buds can be caused by frost even when the other parts of the flower are quite unaffected. Striking cases of this kind have been observed this spring on the Myrobella plum. The bacillus having been isolated from frosted blossoms, from flowers with blackened pistils which may or may not have been caused by frost, and from undamaged fully expanded flowers of the Myrobella, it is evident that for this plant at least the organism is not always pathogenic. At the same time the tissues of the discoloured pistils have been swarming with cells of the bacillus in some instances. Further investigation is necessary before such points can be satisfactorily cleared up.

When the disease was at its height last year in the fruit plantations at this institution one of its most striking features was the rapidity with which it spread from flower to flower. Definite proof was forthcoming that this was due mainly, if not entirely, to the agency of bees and other insect visitors to the flowers. A number of bees were caught in sterilised test-tubes, while they were actually working among trusses of pear blossom. They were transferred to Petri dishes containing a layer of sterile malt extract gelatine, and were allowed to walk over the surface of the latter. In fifty per cent. of the cases examined it was found that colonies of the bacterium with the typical characters to be described later developed in the footprints of the bees after an interval of three or four days. The course of the bees across the plate was most strikingly mapped out by the line of colonies. It is interesting to note that perfectly pure cultures were obtained in some cases in this way, no other organism developing on the plates.

There is no doubt therefore that the dissemination of the disease is largely due to insect visitors to the flowers. Infection is carried by them from diseased to healthy blossoms, which become inoculated either through the stigmas or the points of the viscid receptacle with which the feet of the insects come into contact. It will be seen later that infection can take place by merely superficial inoculation with the organism in this manner.

Probably the start of an outbreak at the beginning of the flowering season occurs in two ways. In the first place it seems likely that in cases where blossom is produced on a spur the tissues of which are already infected with the organism, some of these blossoms are infected at the time of their formation through the spur tissues. In the second place, since the organism has been found in the soil of fruit plantations, it is likely that insects or wind convey infection from that quarter in many cases.

In the light of present knowledge the organism seems to be a form of very wide, if not general, distribution in this country, occurring at times in the soil of fruit plantations and possibly having a natural habitat in the soil. It is frequently found in flowers, especially such as rosaceous species, where a prominent nectar-secreting disc, on which it appears to thrive, is present; becoming parasitic in some cases, notably the pear, perhaps being aided in obtaining entry to the tissues through frost or other damage. It is carried from flower to flower by bees; and finally, in the case of the pear at least, is capable of gaining access to the tissues of the fruit spurs and remaining in an active state there throughout the year.

Infection Experiments.

These experiments have been mainly carried out on pear blossom, flowers of the varieties Catillac, Beurré d'Amanlis, Louise Bonne de Jersey, and Vicar of Winkfield being for the most part used. The number of flowers infected was very large, and the infection was in nearly all cases successful.

The usual procedure in these experiments was to select young healthy shoots bearing blossom in an unopened or comparatively unopened condition, any individual flowers showing traces of natural infection being removed. After infection the shoots were kept in the laboratory or greenhouse at ordinary temperature in covered glass vessels, the atmosphere of which was kept moist by the water in which the cut ends of the shoots were placed. The mode of infection varied. In some cases drops of water containing the bacteria were simply placed upon various parts of the flower by means of a sterilised platinum loop, care being taken to avoid injury to the tissues of the flower. In other cases the culture was applied with a fine needle, the tissues being slightly pricked. It may be added that in all infection experiments pure cultures of the organism were alone used, the usual precautions against foreign infection being taken by the use of sterilised instruments and other necessary

details. It was found that although infection was obtained by both methods, the disease set in much more readily when the tissues were punctured. By the latter method the flowers formed small moist drops in three to four days after infection at most of the injured spots, and on the fifth day distinctly grey coloured slimy colonies could be seen. After six to seven days the affected areas were black and exactly like the natural ones. Microscopical examination of the tissues of these regions showed a heavy growth of the organism, and the latter after isolation in pure culture again presented all the characters of the original type. It is noteworthy that in practically every case tested the bacillus in question was the only one isolated from the affected tissues. In due course the blackening spread to other parts of the flower in the manner already described in connection with the disease under natural conditions. Control experiments in which the flowers were punctured with a sterile needle, but not inoculated with the organism, gave in the large majority of cases negative results. Some discolouration occurred at the point of injury, but nothing further resulted. Where the control experiments in a few cases showed a development of the disease at such points, it is probable that the organism was already present on the flower at the time of injury. There is evidence to show that the bacillus is at times present on the surface of perfectly healthy flowers.

The infection experiments in which the tissues of the flowers were uninjured yielded less striking results, although in the great majority of cases the disease eventually developed.

Owing to the extent of the disease on the trees at Long Ashton last spring, the selection of unaffected blossom trusses for infection experiments was difficult. Many instances of the disease developing without artificial infection on selected trusses apparently quite healthy occurred; and although there is no question of the success of the infection experiments, there were occasions when it was difficult to decide as to natural infection also playing a part.

Infection experiments were also made on flowers on trees growing in the open plantations at this institution. These were less satisfactory than those already recorded. In the first place it was almost impossible to distinguish between the results of artificial and natural infection, the latter being so common, when the infected trusses were not enclosed in paper bags; and secondly, when paper bags were used, a large number of artificially infected trusses remained healthy, the controls behaving similarly. Probably this was due to the effect of bagging on the flowers. While at present we know little as to the influence of external conditions

on the disease, the available evidence indicates that the disease is encouraged by a comparatively low temperature and a damp atmosphere and conversely is checked by hot and dry weather. The conditions within the bags approximate to the latter type.

Since it was discovered that the tissues of the fruit spurs of pears were frequently attacked by the organism several infections were made in young shoots of apples, pears, plums, and gooseberries, by means of needle punctures. Control punctures with a similar sterile needle were made at the same time. The two sets of shoots were compared at monthly intervals, and it was found that, although the inoculated punctures were full of the living bacteria, so much as to show that some multiplication had taken place, the organisms had not spread appreciably in the tissues nor caused more than a minimal amount of local damage. Macroscopically the infected shoots differed in no way from the controls.

A few infections on Catillac pear fruits when they had nearly attained their maximum size were also made by puncture. No serious results ensued.

Isolation, Description, and Cultural Characters of the Bacillus.

As already mentioned, microscopical examination of the tissues of the discoloured areas of the flowers, leaves, and fruit spurs showed them to be swarming with cells of a rod-like bacterium. The detection of the organism was generally difficult and frequently impossible when material for examination was selected from the centre of the blackened patches owing to the alterations in the diseased cells of the tissues. The formation of granular substances and the abundance of comparatively opaque and darkened cell contents prevented satisfactory identification of the presence of the parasite. It is indeed probable that the latter dies off in those places. When, however, portions of the tissues at the periphery of the discoloured spots bordering on healthy unattacked cells were examined, there was generally no difficulty in finding the bacteria in abundance and in a most active condition. There appears to be a zone of the bacteria along the periphery of the affected areas, where fresh cells are being attacked, which advances with the spread of the discolouration ; while behind, where the cells of the host have been killed, the parasite has migrated or died off.

The isolation of the organism from the peripheral portions of affected areas was simple. Plate cultures of malt extract gelatine infected from such regions gave colonies of the bacterium in the course of four or five days. Many independent series of plate cultures have been made from

different flowers, leaves, and fruit spurs, and in the great majority of cases the characteristic colonies of the organism have developed. It was rarely that other organisms appeared on the plate cultures; and in such cases the foreign form was nearly always *Monilia fructigena*, the "brown rot" fungus. It is not uncommon to find flowers attacked at the same time both by this fungus and the bacillus.

The isolation of the bacterium was especially easily effected from flowers showing newly developed small, black spots on the receptacle. By touching these spots with the point of a sterilised needle, and making streaks with the latter over the surface of a sterile plate of the nutrient gelatine, pure cultures were very often immediately obtained. From older, dried up material, the growth is not so quickly developed.

Pure stock cultures of the organism were kept on various nutrient substrata and in liquid nutrients. In most cases the organism retained its vitality for several weeks at least and did not lose its parasitic powers, infections on fresh flowers and leaves giving positive results. In due course, however, on most of the media tested it eventually died off; but cultures on potato blocks have retained their vitality and parasitic abilities for over eight months.

The bacillus is a rod $2–4\,\mu \times ·5–·8\,\mu$ in dimension. Although satisfactory stained preparations of the flagellae have only been obtained in one or two instances after repeated trials, there seems no doubt that the cells are lophotrichic. The flagellae, two or more in number, are at least four to five times as long as the cells themselves. The organism stains well with the usual stains, and especially so with gentian violet. It is also stained by Gram's method.

It grows well in malt extract solution (sp. gr. 1·040), glucose-peptone water (5 % glucose, 1 % peptone), and in neutral and slightly acid (+ 0·15 % normal) bouillon.

The bacillus is highly motile in young cultures, showing quick progressive movements. The motility depends greatly upon aeration. This is very well shown in ordinary coverslip preparations made from colonies or young plate cultures, the bacillus coming to rest in about two minutes at the centre of the slide, the movement being progressively more active in the cells passing outwards towards the edges of the slip. At the latter region or in the neighbourhood of air bubbles movements continue for about 20 minutes. It then ceases and agglutination takes place. After all have come to rest, if the slip is lifted for a few moments and then replaced, nearly all the cells are found in an active state of movement.

The cells are mostly single or in pairs, seldom in long chains. No endospores have been observed in any cultures. Involution forms are produced very readily, especially at temperatures of 25–30° C., and in old cultures. These involution forms attain often a length of about 100 μ and are irregularly swollen. The optimum temperature for growth is about 18° C.

In bouillon at 15–18° C. a slight cloudiness is formed in 24 hours, and a good growth obtained after two days; after four days there is an appreciable deposit and a slight thin film on the surface of the liquid. At 25° C. growth is a little slower, and at this temperature after 48 hours the cells gradually increase in size and begin to lose their motility. Small chains and involution forms are then soon developed, and after four to six days the organism has completely changed its original form. It grows out into long threads and large, irregularly swollen and often very granulated forms. Movement is then practically stopped.

At a temperature of 18° C. the cells do not change their form or lose their motility until the cultures are getting old.

If involution forms from a six-day old culture are placed in fresh bouillon and kept at a lower temperature, the new cells quickly begin to assume the normal size and motility.

In two months old bouillon cultures, the cells collect at the bottom of the vessel, forming a disc of somewhat gelatinous character, and the liquid is left perfectly clear.

With bouillon gelatine stab cultures show feeble development after 24 hours. After 48 hours there is good growth with crateriform liquefaction; after six days the liquefaction is stratiform, and after eight days all the gelatine is liquefied and a flocculent deposit formed. Streak cultures after 48 hours show strong liquefaction, there being a broad concavity in the gelatine and a cloudy liquid and white, flocculent deposit in the tube.

In plate cultures of gelatine media colonies are extremely characteristic after four days. The submerged colonies are small and white, the surface colonies are liquid with smooth edges, round, 6–8 mm. in diameter, concave, moist and glistening, semi-transparent, often with small white nuclei in the centre and concentric rings of granular matter beyond, and with whitish margins. Under the microscope the surface colonies show a flocculent deposit and a margin forming a double ring.

The liquefying action is very pronounced; and in a plate culture the whole gelatine is generally liquefied in about eight days, even if

the plate originally contained only 8–10 colonies. A plate culture in the liquid state has a pronounced smell of ammonia.

In bouillon agar at 18° C. stab cultures give feeble growth in three days, spreading out on the surface. Streak cultures form in three days a flat, glistening, smooth-edged, whitish, spreading growth. In plate cultures the colonies are visible after 48 hours. The surface colonies after three days are small, round, raised, glistening and whitish, later spreading out over the surface. Submerged colonies are white and remain very small.

On potato a raised, yellowish-white, broad, smooth-edged growth is formed after eight days at 18° C. On parsnip and carrot a feeble growth is observed after five days. On turnip no development takes place.

In sterilised milk a good growth is obtained. No curdling takes place in eight days at 18° C., but the milk is eventually very slowly peptonised.

No fermentation takes place in 2 % solutions of saccharose, maltose, glucose, laevulose, or lactose, to which 1 % peptone was also added.

Old cultures in glucose-peptone solution exhibit a pronounced greenish fluorescence. This has not been observed in the case of any other media.

There is no indol reaction given in eight-day old cultures.

From these characters it appears that the organism is a species of Pseudomonas. So far it has not been identified with any hitherto described form; but on account of its wide distribution and occurrence in the soil it is possible that it may be known to soil bacteriologists as one of the ammonia-forming types.

ON THE PREPARATION OF COCCIDAE FOR MICROSCOPICAL STUDY.

By E. E. GREEN.

1. *Introductory Notes.*

Having been asked by several correspondents to describe the best method of preparing *Coccidae* for critical study, I have thought it might be useful to publish an account of the technique that I have adopted in my own work. I do not set it up as being the best method, as I have not experimented to any extent in other directions: but I have gradually arrived at a procedure that appears to produce satisfactory results which compare favourably with examples of mounting that I have received from other working entomologists. I am, however, confident that useful modifications and improvements could be effected by anyone conversant with the processes employed in modern laboratories. I must also confess that I work largely by rule of thumb and have not reduced my processes to exact measures of time and quantities. I find, indeed, that the essence of success depends upon minute variations in the treatment employed—to be learned by actual experience alone.

2. *Appliances and Reagents.*

I will first give a detailed list of the appliances and reagents that I have found necessary or convenient:

Any good compound microscope, with modern objectives.
A dissecting microscope (preferably an erecting binocular).
An Abbe-Zeiss camera lucida.
A reliable stage micrometer.
Fine-pointed forceps.
Small scalpels.
Dissecting scissors.
Two or three fine camel-hair brushes.

Some "snipe-points" (the terminal feather of a snipe's wing) mounted in small porcupine quills.

Setting needles. These should be the smallest and finest obtainable.

A small (narrow) section lifter. A piece of stout silver wire, hammered flat at one end and turned up at a slight angle, serves the purpose admirably.

Evaporating dishes ($2\frac{1}{2}$ in. diam.).

Several flat-bottomed watch glasses.

Short test-tubes (1 in. diam.).

Excavated glass blocks. These may take the place of the watch glasses, as they are most useful for the reception of such reagents as oil of cloves, distilled water and various strengths of alcohol, in which the objects have to be steeped for various periods. They will stand steady on the stage of the dissecting microscope.

Glass pipettes with rubber teats.

A small glass table, with a mirror below, is of great convenience when transferring objects from one medium to another.

The following reagents will be required:

A strong solution of potassium hydrate (liquor potassae).

Alcohol, 70 %, 90 %, and absolute.

Fuchsin (acid), strong aqueous solution.

Picric acid, saturated solution in alcohol.

Glycerin, dilute.

Oil of cloves.

Canada balsam, dissolved in xylol.

Distilled water.

3. *Preparation and Mounting of Specimens.*

Coccidae do not necessarily require any prolonged process of preliminary preparation. They may be treated in the fresh condition without any difficulty. On the other hand, material that has been kept in alcohol or other liquid preservatives, or that has remained dry for many years, will respond to treatment with complete success—provided that it has not been allowed to become mite-eaten or infested with fungus.

Naked species, such as *Lecanium*, are the simplest subjects and may be best utilised to illustrate the process. The general procedure is the same for all *Coccidae*; but slight modifications (to be noticed later) will be necessary in particular cases.

Let us suppose that we have some dried leaves or twigs infested with a species of *Lecanium*. Detach a few of the insects by means of a needle or fine scalpel, taking care not to injure the margin in so doing. Select examples of different stages of growth, and take more than will be actually necessary for the final mount. Some of them are sure to be imperfect and may be discarded during the later stages of the preparation. Place the selected specimens in a small evaporating dish, together with a tiny fragment of pumice stone (to prevent too violent ebullition). Add about two teaspoonfuls of strong potash solution and heat over a spirit lamp for from two to five minutes, agitating the vessel slightly and regulating its distance from the flame so as to keep the liquid simmering rather than actively boiling. If it is necessary to prepare several different species at the same time, specimens of each may be isolated in small test-tubes (with the requisite amount of potash), plugged with cotton wool and placed erect in a small saucepan containing water, the whole being boiled together. The specimens must be examined at intervals and removed so soon as they begin to show signs of clearing. The right moment can only be learned by experience. If not treated long enough, there will be subsequent difficulty in removing the contents of the body If treated for too long a time, the cuticle will become too tender and will tear or break up during subsequent manipulation.

During this process, note any colour given off by the objects. Certain species colour the liquid pink—or even crimson ; others give off a greenish, brownish, or inky stain. A knowledge of such characteristics may be of assistance in differentiating between closely allied species.

Remove the prepared specimens, by means of the section lifter, to distilled water. Here, by a process of osmosis, further clearing will take place and part of the contents of the body will pass out into the water. I find it convenient to leave the objects in this medium for 24 hours, and I use the excavated glass blocks for their reception.

At this and all subsequent stages care must be taken to label the specimens in such a manner that they may be identified with the material from which they have been taken. This label should be transferred from vessel to vessel at each subsequent transference of the specimens. Failure to observe this precaution may lead to most unfortunate mistakes.

Before further treatment, note the form of the insect which will often have become distended to its fullest extent, when it may show characters that will be lost under subsequent compression. For instance, the lateral tentacular processes characteristic of the living

Diaspis boisduvallii usually disappear entirely when mounted in balsam. The peculiar form of the *Tachardia* insect is best shown (and figured) at this stage.

It should also be noted whether the bodies contain well developed ova or embryos. The presence of such will settle conclusively the stage of the insect, in doubtful cases.

On the following day the specimens should be transferred to clean water, when the remaining contents of the body may be easily removed by manipulation with fine needles, assisted by the mounted snipe feathers. If the body is not already ruptured, a small opening should be made at one point, through which the liquid contents may be gently worked out. Small aggregations of wax, fatty globules, or partially solid matter may be removed by inserting a fine point through the artificial aperture.

The specimens are next transferred to and washed in 70 % alcohol for a few minutes. They are now mounted temporarily on a glass slide in a drop of dilute glycerine, under a glass cover slip, for preliminary examination. After which, a few drops of fuchsin solution are run in with a pipette, and the slide is put by for another 24 hours.

Then add a few drops of picric acid solution and leave for five or ten minutes, to fix the stain.

Remove the cover glass; flood the slide with alcohol, to redissolve the partially crystallised picric acid, and transfer the objects to a bath of 70 % alcohol, where the glycerine and superfluous stain can be washed out, together with any small fragments of the body contents that may have been overlooked during the earlier process. Such omissions can now be readily detected, as they will have absorbed a deeper stain.

When the removal of the stain has proceeded to the right point, the objects may be washed in absolute alcohol, preparatory to their removal to a bath of oil of cloves, though I have not found any ill effect following upon their direct transference from 70 % alcohol. They may be allowed to remain in the oil for about 10 minutes, after which they are finally mounted in canada balsam.

If the same receptacles and media are used on subsequent occasion great care must be taken that every specimen has been removed. Confusion and erroneous determinations have occasionally arisen through the accidental inclusion in the finished mount of one or more specimens inadvertently left over from a previous operation.

After arranging the objects neatly in the centre of the slide, I place a sufficiency of balsam on the underside of the cover glass and lower it gently on to the specimens. I used, at first, to find that the balsam,

when spreading itself under the cover glass, would disarrange my neatly disposed specimens, and even carry some of them away to the extreme margins. I now prevent this inconvenience by pressing the objects on to the glass with a small piece of thin smooth blotting paper. This absorbs the remaining oil of cloves and makes the objects adhere closely to the glass. Before adding the balsam and cover glass, the mount should be examined for the removal of any small fibres that may have detached themselves from the absorbent paper. Several specimens should be mounted on one slide, some showing the dorsal and others the ventral surface uppermost.

When dealing with strongly convex species, it is often advisable to slit the dorsum, as otherwise it will not lie flat on the slide. In such cases the venter should be separated from the dorsum and disposed so that the two surfaces can be examined side by side.

Species that are densely coated with wax, such as *Ceroplastes*, should have the waxy covering removed before the insect is boiled in potash. This can usually be done with a fine scalpel, without injuring the insect; or the wax may be dissolved in carbon bisulphide. Boiling in oil of cloves will have the same result.

The larger species of *Monophlebus* and allied genera are often so dense that satisfactory mounts cannot be made of the complete insect. It is better to divide them horizontally, separating the venter from the dorsum completely. If the insects have been preserved in alcohol, this section can be effected before boiling in potash. But, with dried examples, it is necessary to boil them for a short time, until the skin is softened, before attempting the operation. The object is then replaced in the potash and boiled until the two halves come apart and the soft inner tissues separate from the derm, leaving the latter quite clean.

The species of *Tachardia* (lac insects) are embedded in dense resinous gum which may be softened or completely dissolved by immersion in strong alcohol, before treatment.

Coccidae of the family *Diaspidinae* are concealed beneath composite scales consisting of the larval exuviae supplemented by secretionary matter. To obtain the insect itself, the scale must be lifted or turned over when the creature will be found either free or lying in the hollow of the overturned scale. If there is any difficulty in extracting the insect, the whole scale may be boiled in potash, when the secretionary matter is decomposed and the insect and pellicles freed. Some of these pellicles should be stained and mounted with the insect itself, as they often afford useful characters for the differentiation of closely allied

species. In the absence of male puparia it is often difficult to decide whether a certain species should be included in the genus *Aspidiotus* or *Diaspis*. Examination of the larval and nymphal pellicles of the female will usually decide this point, for in *Aspidiotus* the dorsal half only of the pellicle is present in the scale, whereas in *Diaspis* the venter remains attached and will be found beneath the posterior extremity of the pellicle.

In the genera *Aonidia*, *Fiorinia* and *Leucaspis*, the adult female is completely enclosed within the nymphal pellicle, and it will be necessary to break this open (with a fine needle) to obtain the actual insect.

Insects of the genus *Asterolecanium* require very careful handling. The derm is exceedingly thin and delicate. A very short immersion in boiling potash is sufficient to soften the tissues and decompose the contents of the body. I find it best to place the complete scale in the potash and continue the boiling only until the secretionary matter is dissolved, when the insect—now freed from its covering—should be immediately transferred to distilled water.

The treatment must be modified when dealing with adult males of any of the smaller species. Boiling in potash results in the hopeless crumpling of the wings and their entanglement with the other limbs. For such delicate objects a more prolonged immersion in cold potassium hydrate is preferable.

The procedure may be roughly summarised as follows:

(1) Boil in potash for a few minutes, or immerse in cold potash for a longer period, until the contents of the body are completely softened.

(2) Soak in distilled water for 24 hours.

(3) Press out the softened contents, and clean the surface parts.

(4) Mount temporarily in dilute glycerine.

(5) Stain with fuchsin, for 24 hours.

(6) Fix stain with picric acid for 5 or 10 minutes.

(7) Wash and remove superfluous stain in 70 % alcohol

(8) Wash in absolute alcohol.

(9) Place in oil of cloves for 10 minutes.

(10) Mount finally in canada balsam.

4. *Preservation of Unmounted Specimens.*

A few hints for the preservation and storing of unmounted material may be of use.

Desiccation is the method usually adopted and—for a general collection—is certainly the most convenient; though, where it is desired to retain the exact form of the fresh insects, it may be advisable to preserve duplicates in alcohol or dilute formalin.

A very large number of species, *e.g.* all the *Diaspidinae* and the flatter forms of *Lecanium*, may be treated like botanical specimens, *i.e.* dried, together with the leaves to which they are attached, between absorbent paper. But the pressure employed should be light—merely sufficient to keep the leaves flat. I frequently have material submitted to me for determination, where no pressure at all has been employed, with the natural consequence that the leaves are so curled or shrivelled that the task of examination is greatly aggravated. In such cases it is necessary to break up the whole material and to examine it very closely or valuable specimens may be overlooked. A leaf that has been dried flat may be completely examined with the maximum of convenience in the minimum of time. Thin slices of bark, or rind of fruits, may be treated in the same way. Twigs bearing specimens may be cut up into convenient lengths and dried without pressure. In any case, superfluous and useless parts should first be removed, to facilitate subsequent examination and save space. Leaves bearing hemispherical or highly convex species may be dried flat without pressure by pinning down the edges. Species that are not habitually attached to their host plant, such as many species of *Pseudococcus*, *Orthezia*, etc., are best removed and dried separately, after which they may be kept in small glass tubes plugged with cotton wool, or, better still, in the small gelatine capsules supplied by chemists for the reception of various drugs. Specimens dried *in situ* should be wrapped in soft paper and placed in small envelopes upon which the full data should be written. Capsules or tubes should be placed in similar envelopes. The envelopes themselves may be conveniently stored in white cardboard boxes which should be made to order and should be of various sizes which must be multiples of the smallest unit. The sizes that I have adopted in my own collection are:

$$1\tfrac{3}{4}\times 2\tfrac{3}{4}\times \tfrac{1}{2}\ ;\quad 1\tfrac{3}{4}\times 2\tfrac{3}{4}\times 1\ ;$$
$$1\tfrac{3}{4}\times 2\tfrac{3}{4}\times 2\ ;\quad 1\tfrac{3}{4}\times 2\tfrac{3}{4}\times 4.$$

The drawers of my cabinet have an inside measurement of $17 \times 16 \times 2$ inches deep, each of which will hold six rows of 30, 15, 8 or 4 boxes, according to the size. With the exception of the largest size, the boxes stand edgeways in the drawer.

Each box should be reserved for a single species only, but may contain several gatherings of that species. The name of each species should be clearly indicated on the cover of its particular box. The various genera will naturally be grouped in their respective families, but it will be found convenient to arrange the species alphabetically, under their respective genera. A small quantity of finely powdered naphthalin should be placed in each box, and renewed periodically. If preferred, naphthalin dissolved in petrol or benzine may be employed. A few drops of this liquid will spread over the bottom of the box and, upon evaporation, will leave a fine deposit of naphthalin which has the advantage of not shifting its position when the boxes are placed on edge.

Specimens preserved in a liquid medium (for which alcohol of about 80 % or formalin diluted to about 3 % may be employed with satisfactory results) must be kept in tightly corked tubes. These do not lend themselves so conveniently to arrangement in the general collection. They must be stored in separate racks, or in boxes fitted with compartments for the purpose.

Glass slides with microscopical preparations can be stored in any of the various forms of boxes or cases designed for the purpose. I use cases made in book form, each case containing 50 slides, with an index on the inside of the cover. Such cases can be arranged like volumes on book shelves.

Surplus material should always be retained, for purposes of exchange. Great convenience and economy of time will be experienced if such duplicates are at once portioned out and placed in labelled envelopes, ready for distribution when required, instead of being stored in bulk. When an application for specified duplicates is made by some correspondent, the time required to go through a large collection, separate out the required material, do it up in packets and label it, is often greater than can be given at the time. The task is therefore postponed for some more favourable opportunity which may be indefinitely delayed. I keep all my duplicate material in small labelled envelopes which are stored (alphabetically) in tin boxes made especially to fit them. Any species can then be found instantly and is ready, without further attention, for distribution.

5. *The Importance of Exact Measurements.*

Finally, I should like to say a few words on the importance of exact measurement in critical comparisons. For this purpose a camera lucida is almost indispensable. Take, for instance, the determination of the antennal formula. Direct measurement of such minute parts is extremely difficult; but, if enlarged camera drawings are made, they can be compared and measured with the greatest facility. Neither the eye alone, nor freehand drawings can be trusted implicitly. Body measurements alone are not of much value between closely allied species, as individuals from a single colony often vary considerably in size, and such variability is still more marked between examples collected on different plants. But the more densely chitinous parts—antennae, limbs, anal lobes, etc.—are much more constant. After the final moult these organs do not increase in size, though the body of the insect may more than double its original dimensions.

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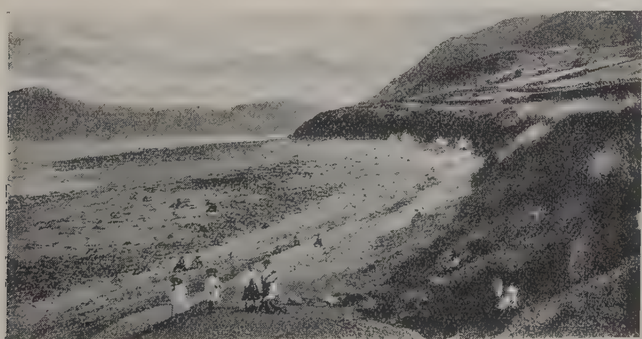

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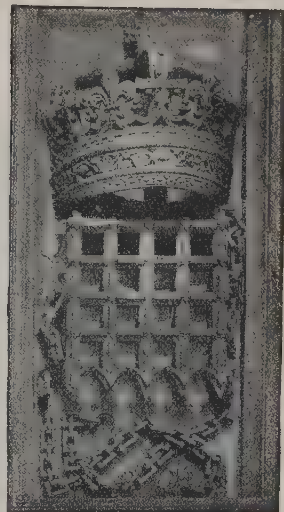

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> "The origin of *Cambridge* as an *University* is very doubtful. We are however informed that one Cantaber, a Spaniard, about 370 years before Christ, is intitled to this honour; Certain it is, that after many years laying desolate, Sigebert, King of the East Angles, restored it A.D. 630."

Except for the year 1798, the Calendar has appeared annually since 1796. In 1803, the title was temporarily changed to *The Cambridge University Register*, and the following year's issue, edited by "a member of the Senate," was dedicated to William Pitt and the Earl of Euston.

It was printed at the University Press in 1803 and 1804, and this has also been the case from 1826 to the present time.

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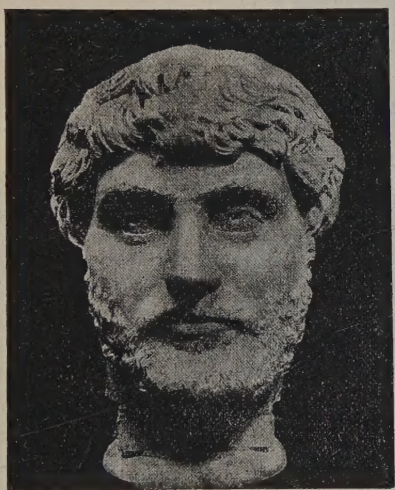
Carpentum of Agrippina the elder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